DATA MANAGEMENT

FOR

CAD APPLICATIONS

A Thesis Submitted in

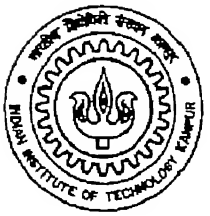
Partial Fulfillment of the Requirements

for the degree of

MASTER OF TECHNOLOGY

by

Manoj Kumar Sinha



DEPARTMENT OF MECHANICAL ENGINEERING

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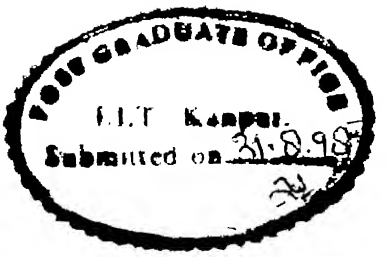

CERTIFICATE

This is to certify that the work contained in the thesis entitled, "**DATA MANAGEMENT FOR CAD APPLICATIONS**", by ***Manoj Kumar Sinha,*** has been carried out under my supervision and that this work has not been submitted elsewhere for a degree.

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August, 1998

Dedicated

To

Thy

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NOMENCLATURE

CAD	Computer Aided Design
CADD	Computer Aided Design & Drafting
DBMS	Database Management System
SQL	Structured Query Language
FDM	Fused Deposition Modeling
DOS	Disk Operating System
BOM	Bill of Material
ASE	AutoCAD SQL Extension
ASI	AutoCAD SQL Interface
ODBC	Open Database Connectivity
QBE	Query By Example

ABSTRACT

Automation is a long tradition on the factory floor, where the constant objective has been to increase the productivity of manufacturing processes. Industry requires an integrated database-cum-CAD package to archive the database (bill of material) along with the drawing whenever needed. However, one of the main bottleneck in the development of methodology is the standardization of the drawing details and database structure which is accomplished in the present work.

In the present work AutoCADR14 and dBaseIII Plus is used for "*Database management for CAD*". Drawings are generated according to the standard defined methodology in the environment of AutoCAD R14. Structure of database is prepared and reports are generated in the environment of dBaseIII Plus. Programming is also done in the environment of dBaseIII Plus to accomplish relational database design.

Integration is a matter of cooperation between systems, each dedicated to a particular set of tasks in the industrial process. The work include development of links between the drawing and the corresponding database with the objective of developing integrated databases which is essential for the technical infrastructure.

Requirement of bill of materials associated with a drawing is frequent in the industry. To meet the need, an environment is created to establish a link between drawings generated and the associated database (bill of materials). This helps to archive the associated bill of materials with the drawing immediately on requirement. The link developed is unidirectional in nature. Program is written in the environment of AutoCAD R14 to customize its menubar to have more user-friendly approach to the problem.

Chapter 1

INTRODUCTION

1.1 DEVELOPMENTS IN DESIGN OFFICE AUTOMATION

The engineering drawing has been an integral part of industry for many years. It is the link between engineering design and manufacturing. Information is quickly communicated to manufacturing in the form of drawing prepared according to prescribed drafting standards.

The word *graphics* means dealing with the expression of ideas by lines or marks impressed on a surface. A drawing is a graphic representation of a real thing. Drafting, therefore, is a graphic language, because it uses pictures to communicate thoughts and ideas and is referred to as the *language of industry*.

The drafting office is the focal point for all engineering work. The last thirty years have brought great changes to the drafting room. Engineering has changed from using mathematical tables; to slide rules, to pocket calculators, to personal computer. For decades, drawing has been produced with pen and pencil. Draftsman with the aid of drawing board, pencil, and other drafting instruments prepared drawing. Then electronic drafting era came. The drafters and engineers have moved quickly from their battered domain of old into the information age. Largely the integrated chip circuit brought about these changes. Drafting and design have been at the forefront of all the changes. Interactive computer graphics and CAD technology have been impacting the drafting, design, and manufacturing tools significantly. Different people have utilized CAD in different ways. It can be utilized to produce drawings and

document design, used as a visual tool by generating shaded images and animated displays, used to perform engineering analysis, etc [4].

Computer Aided drafting system relieve the drafter and designer from tedium. Drawings now can be revised and changed much more quickly and accurately. Reducing drafting time in a company is of prime importance.

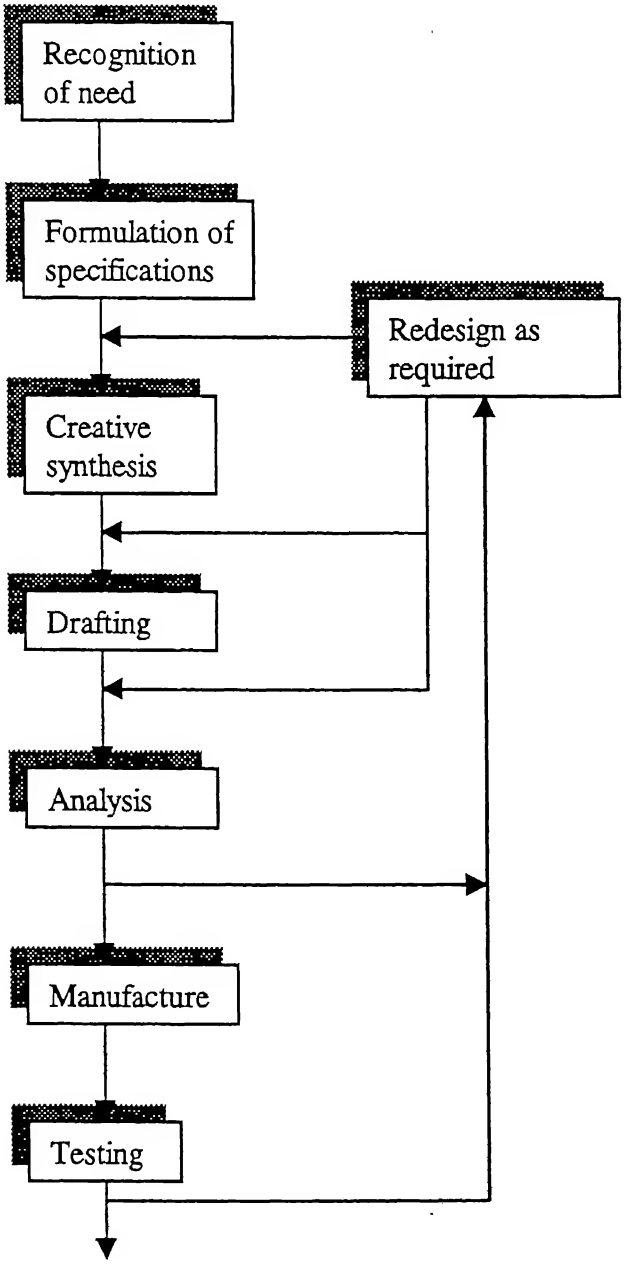


Fig. 1.1 The design process

CAD delivers draftsman from tedious and repetitive tasks. This includes such skills as lettering and differentiation of line weights, etc. CAD thus enhances creativity while it quickly performs the task of showing the ideas.

Computer Aided drafting and design software packages takes advantage of the computer's ability to store, process, and retrieve information. A designer describes the proposed design and then displays it on the computer monitor. The system enables the designer to view a proposed machine part from various locations and to produce a hard copy. Design changes can be made quickly and inexpensively at this point. The design process has the steps as shown in Fig. 1.1.

In addition, CAD can be used to create an accurate three-dimensional (3-D) geometry database, produce a bill of materials, and create a prototype via stereo-lithography. Thus, CAD can reduce concept-to-production time, improving competitiveness. CAD has a variety of capabilities; each designed to meet a different engineering need.

1.2 DATABASE .....An Overview

A database is a collection of related data with multiple uses. A system is needed that will integrate the data files into a database and that can provide different views to different users. The software, the hardware, the firmware, and the procedures that manage the database comprise a database management system (DBMS). A database management system makes it possible to access integrated data that crosses operational, functional, or organizational boundaries as shown in Fig. 1.1 [11].

A database management system (DBMS) uses a data model as its underlying structure. A data model embodies the relationships between the entities. Brief descriptions of the popular database models are as follows:

- *Relational database*: Data is stored in tables, called relations that are related to each other. The relations are stored in files, which can be accessed sequentially, or in a random access mode.

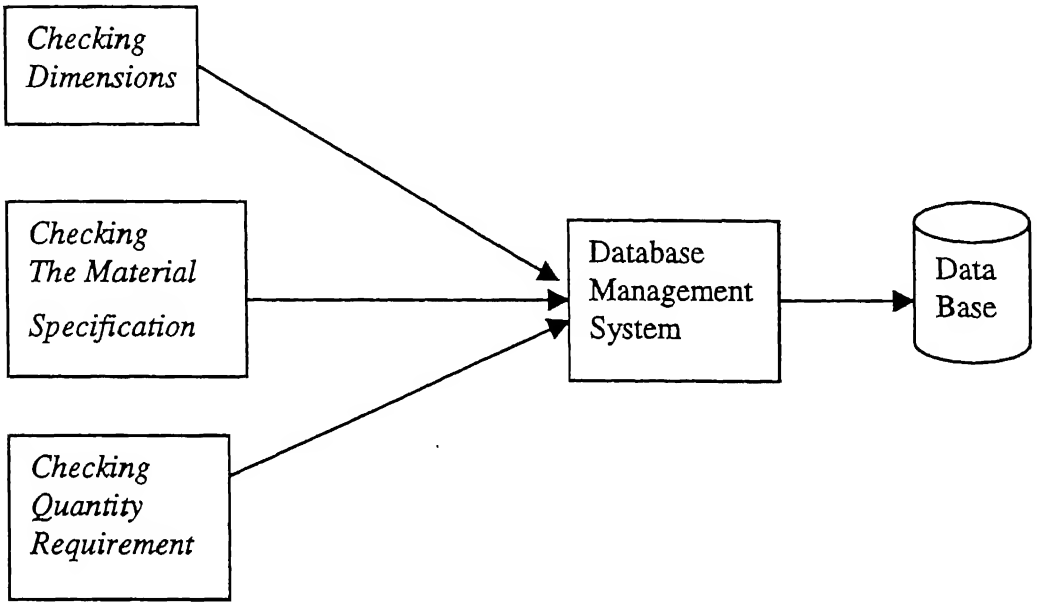


Fig. 1.2 Database management system (DBMS) allows the use of data that crosses the operational, functional, or organizational boundaries.

- *Hierarchical database*: In this model, data is represented by a tree structure. The top of the tree is usually known as the *roots and* the superiority, or hierarchy, of the tree levels relative to each other descends from the root down. The relationship established between a dominant and a subordinate entity type is one-to-many.
- *Network database*: The network approach permits modeling of many-to-many correspondence more directly than the hierarchical approaches. This means that any entity can participate in an unlimited number of relationships.

Other database models are object oriented database model, hybrid database models, and etc. [5].

1.3 OBJECTIVE OF THE PROJECT

In industry the need of drawings are frequent to work with the problems. Many a times the data associated with a particular drawing is also required. Conventional procedure of finding a drawing from a big bunch and then searching after the bill of materials associated with that drawing consumes too much time and hence results in loss of man-hour and productivity. So the need was felt to overcome the conventional procedure.

The thesis is based on an industrial problem given by SIL (Scooters India Ltd., Lucknow). As the need was felt to use advanced CAD-CAM packages in the industry to improve the quality of the product and productivity to compete in the global market, the management decided to change from the old conventional method of generating drawing with the aid of drafting instruments and maintaining a very long catalogue for bill of materials.

The objective of the project can broadly be classified into three categories:

- Generation of drawing.
- Design & development of database for bill of materials.
- Establishing link between drawing & the corresponding database.

1.4 SCOPE AND LIMITATIONS

Generating drawing on a package has numerous advantages, like, the drawing can be modified within very less, tedious and repetitive tasks can be performed easily, drawing can be linked to its database, prototype model of the drawing can be created using FDM (Fused Deposition Modeling), etc.

There are numerous reasons to link part on a drawing to an external database. The most obvious reason is to keep the bill of materials related to the drawing. Once

the generated drawing is linked to its corresponding database then the data (bill of materials) can be recalled immediately by selecting the graphic/non-graphic attributes, which is the base for linking. In industry, the bill of material is quite important. It gives answer to many frequent questions like: how many nuts and bolts a part contains, what is its specification, whether a part is manufactured in-house or is it a vendor component, whether heat treatment is required, etc.

The software tools were selected to match with those already in use by the SIL. Presently, AutoCADR14 is being used by SIL to create their drawings. This sets some boundaries for the present project such as:

1 CAD displays on a video screen is very small due to limitations of the size of the screen and so to have a closer look *zoom* command is required.
2 The environment supported for external database in AutoCADR14 is dBaseIII, ODBC & Oracle.
3 dBaseIII is a DOS based package, so does not provide a bi-directional linkage.
4 Programming in dBaseIII environment is limited by file size.
5 Database can be opened only in the environment of AutoCADR14, i.e., first drawing should be opened in AutoCADR14 and then the associated database (bill of materials) can be called.

It is possible to use the other more versatile DBMS software such as Oracle-11, dBaseIV, etc. The motivation for using dBaseIII has been because of its easy availability and familiarity and urge to start off and demonstrate the linking of AutoCADR14 drawings with the corresponding database. The bi-directional linkage between AutoCADR14 drawings and the database remains to be further investigated using other packages such as Oracle.

Chapter 2

DESIGN AND DEVELOPMENT OF CAD DRAWING FOR A VEHICLE

2.1 DESIGN OF CAD FILES

The basis of CAD file design is hierarchical. A hierarchical tree structure is made of nodes and branches as shown in Fig. 2.1. A node is a collection of data attributes describing the entity at the node. The highest node of a hierarchical tree structure is called a ROOT (e.g., the chief executive officer of an organization). The dependent nodes are at lower levels in the tree. The level of these nodes depends on the distance from the root node [12].

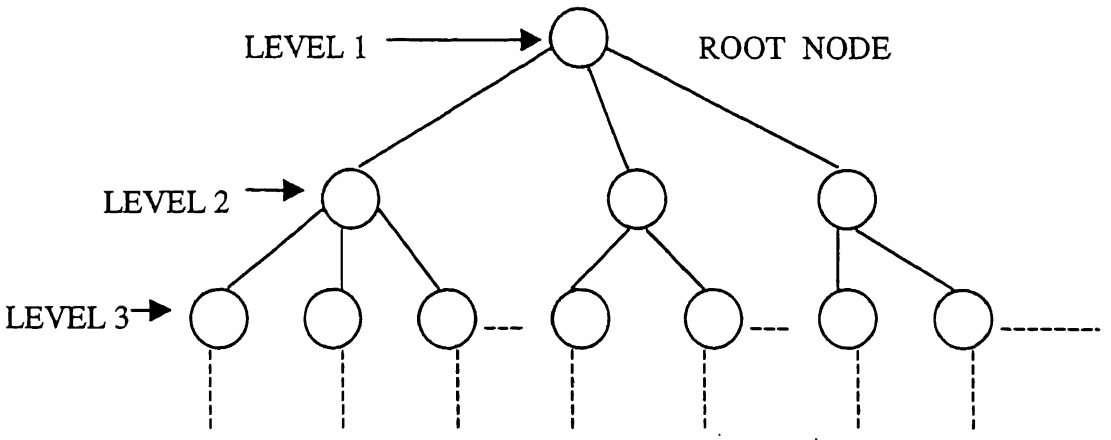


Fig. 2.1 A hierarchical tree structure is made up of nodes and branches.

A hierarchical tree structure has to satisfy the following conditions [10]:

1. A hierarchical data model always starts with a root node.

2. Every node consists of one or more attributes describing the entity at that node.
3. Dependent nodes can follow on the succeeding levels. The node on the preceding level becomes the parent node of the new dependent nodes. The dependent nodes can be added horizontally as well as vertically with no limitations (except at level 1).
4. Every node occurring at level 2 has to be connected with one and only one node occurring at level 1. Every node occurring at level 3 has to be connected with one and only one node occurring at level 2, and so on.
5. Every node except, of course, the root has to be accessed through its parent node.
6. Parent and children nodes have one-to-many relationship.

The arrangement of CAD drawings that are generated on AutoCADR14 are shown in Fig. 2.2.

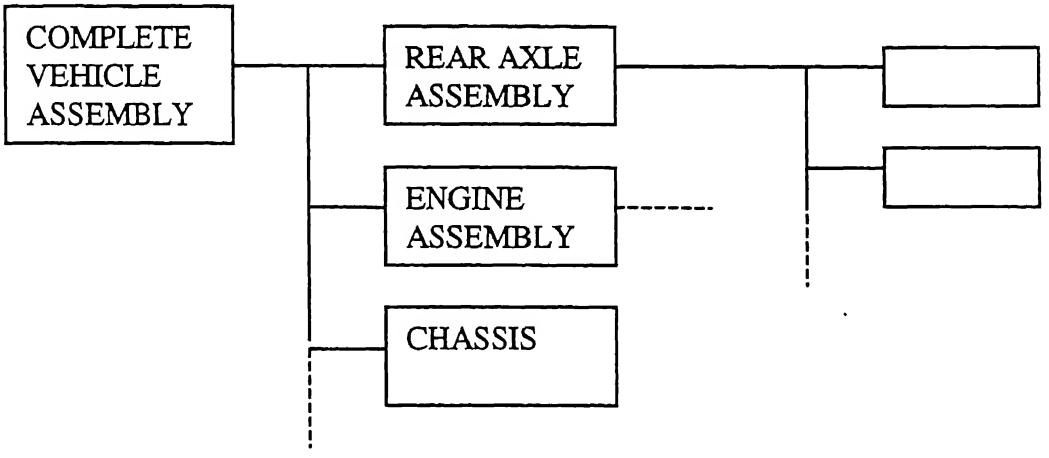
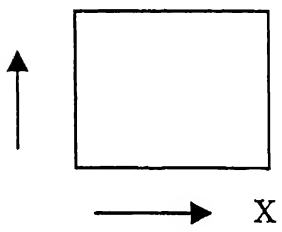


Fig. 2.2 Arrangement of CAD drawing files

In the thesis the complete rear axle assembly is only taken for illustration. The drawings are generated on the AutoCADR14 package. Here the complete vehicle assembly is the root node (dominant entity type) and rear axle sub-assembly is the dependent node (subordinate entity types) at the second level.

2.2 ISSUES OF GEOMETRY

Technical drawings often include borders and title blocks along with other drawing format items. Drawing limits should always be set to match standard drawing sheet sizes. Using standard drawing sheet sizes help ensure that the drawing will always match standard printer and plotter paper size. Fig. 2.3 lists standard size drawing sheet sizes (drawing limits). Fig. A2.1, A2.2, and A2.3 of Appendix-II shows the template design for A4, A3, and A2 size drawing respectively [3]. Template design of the table is shown in Fig. A2.4 of Appendix-II.



	MILLIMETERS	
	X	Y
A4	297	210
A3	420	297
A2	594	420
A1	841	594
A0	1189	841

Fig. 2.3 Standard size drawing template

The drawings generated takes the base of orthographic views to have two-dimensional views of three-dimensional objects. Orthographic views are positioned on a technical drawing so that the top view is located directly over the front view and the side view is directly to the right side of the front view, as shown in Fig. 2.4. The drawings are in first angle of projection.

Sectional views are used in technical drawing to expose internal surfaces. They serve to present additional orthographic views of surfaces that appear as hidden lines in the standard font, top, and side orthographic views. Sectional views do not contain hidden lines. The intent of using a sectional view is to clarify orthographic views that are difficult to understand because of excessive hidden lines, as shown in Fig. 2.5.

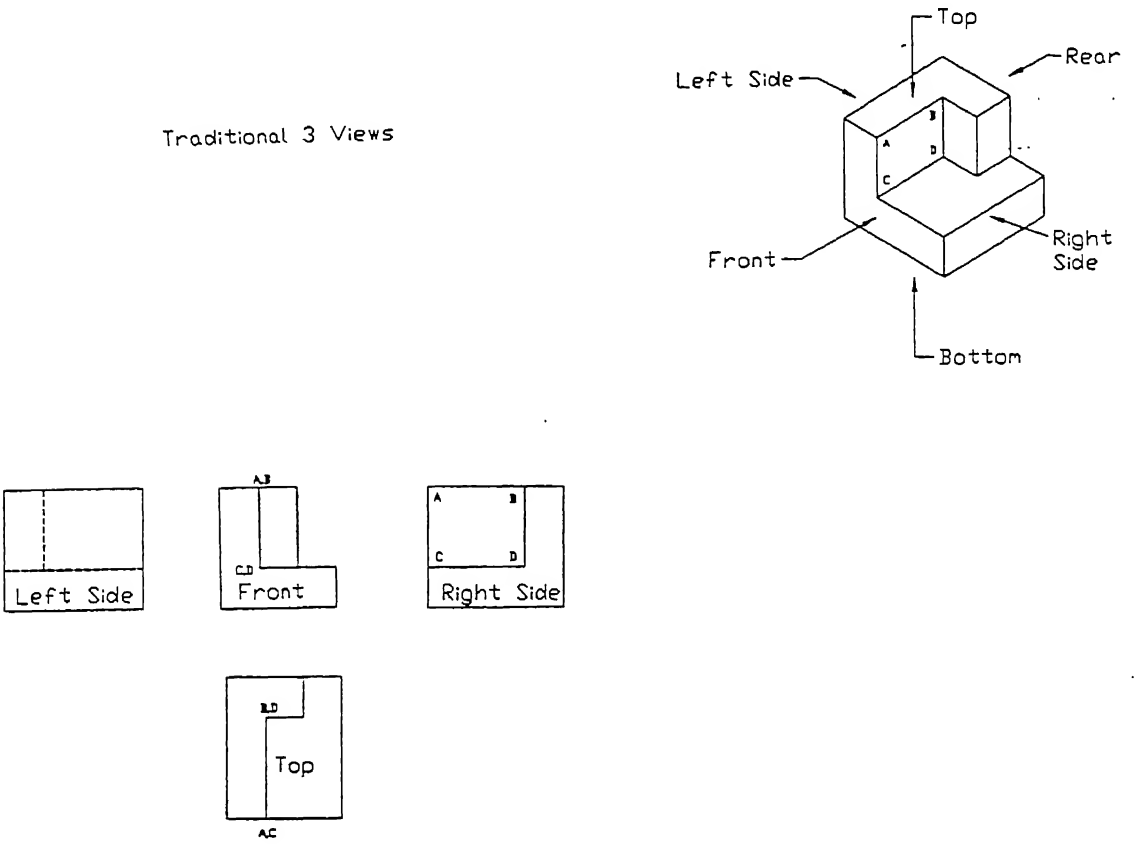


Fig. 2.4 Orthographic view of an object in first angle of projection

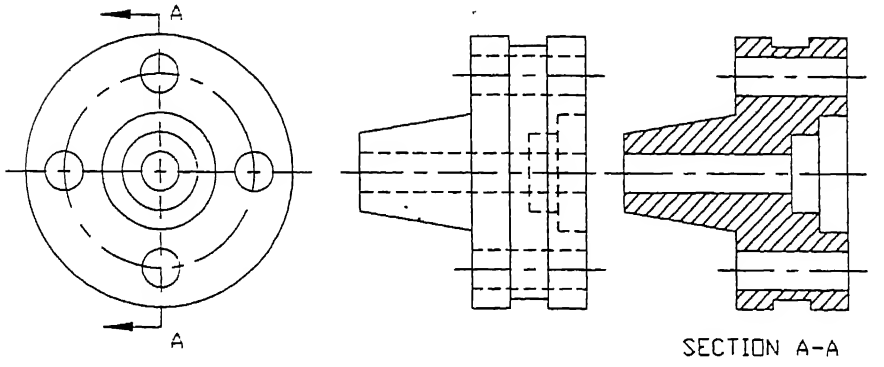


Fig. 2.5 Sectional view of an object with complex internal surface

Sectional view is always viewed in the direction defined by the cutting plane arrows and is located on a drawing behind the arrows. The cutting plane lines need not be straight across the surface of an object. It may be stepped so as to include more feature to the sectional view. Section can be offset section, multiple section, aligned section, etc.

2.3 DIMENSIONING

Dimensioning is based on the standards presented by the American National Standard document ANSI Y14.5 [3] and IS standards i.e., IS:11669-1986.

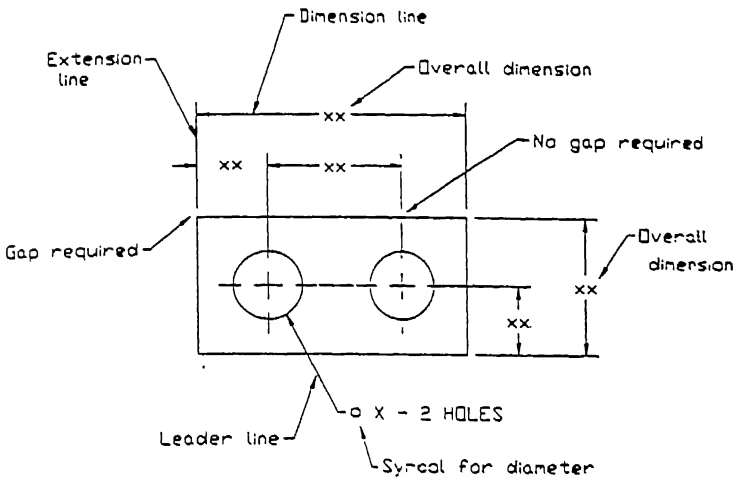
2.3.1 DIMENSIONING TERMINOLOGY AND CONVENTIONS

The drawings follow in general the conventions used in IS:10711 to IS:2709. A dimensioned object is shown in Fig. 2.6. Linear drawing units for drawings are in millimeters. Dimensions should not be located on the surface of the parts. *Extension* lines are used to move the dimensions away from the object. There should always be a gap between the edge of an object and the origin of an *extension* line. This helps create a visual distinction between where the object ends and the *extension* line begins.

Centerlines may be extended and used as *extension* lines. The centerlines are extended directly with no gap as the line passes over the edge line of the object.

Dimension lines are between or around the *extension* lines. *Arrowheads* are placed at the end of *dimension* lines. The *arrowheads* should touch the *extension* lines.

Dimension lines should never be located closer than 10mm from the edge of the object. *Dimension* line should be located at least 6mm from each other. A spacing of 10mm can be used for the distance between the dimension lines as well as the distance from the edge of the part.



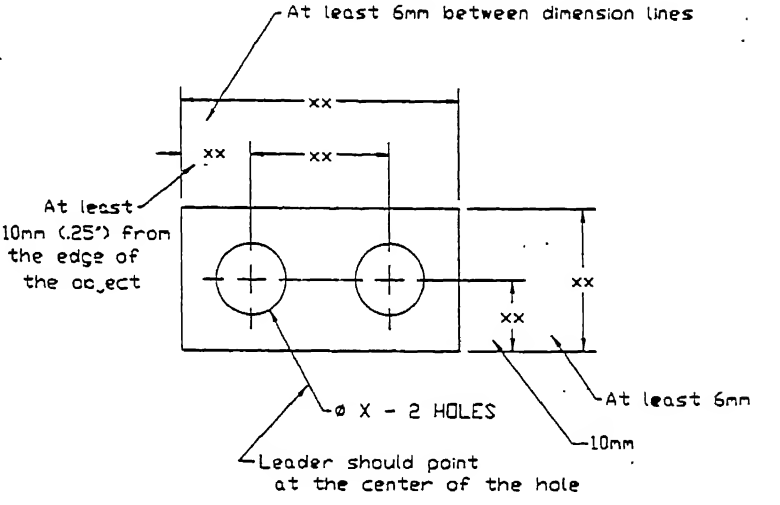


Fig. 2.6 A dimensioned object to illustrate the dimension conventions

Dimensional values are placed within the *dimension* line. There are several different ways to locate dimensional values in relation to *dimension* lines, depending upon the distance being dimensioned.

Crossing *dimension* lines and *extension* lines is avoided as shown in Fig. 2.7. Shorter *dimension* lines are placed closed to the object's edge than longer *dimension* lines. Dimensions that define the object's length, width, and depth are called overall dimensions and should be located the furthest away from the object.

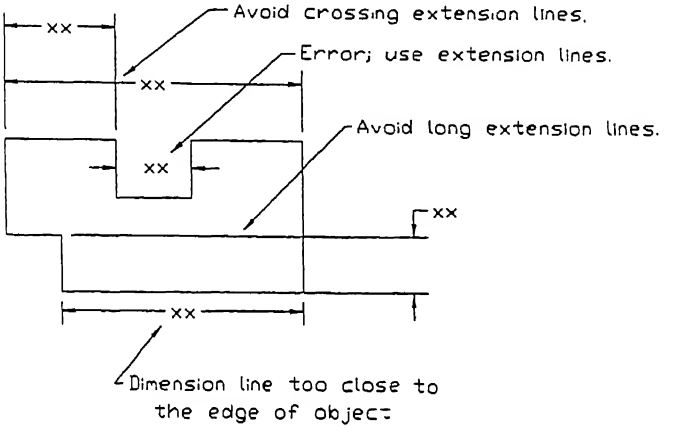


Fig. 2.7 A dimensioned object

Leader lines are used to dimension holes and other rounded shapes. Leader line should start with an *arrowhead* and a line that points at the center of the hole. *Leader* lines are drawn at an angle that clearly differentiates them from any edge lines in the object. *Leader* lines should end with a short horizontal segment.

AutoCADR14 has many different lettering fonts available, but the default style is acceptable in favor of simple, easy-to-read fonts. Dimensions are created with AutoCADR14 using the *DIM* command.

2.3.2 SYMBOLS

Symbols are used in dimensioning to help accurately display the meaning of the dimension. Symbols also help eliminate language barriers when reading drawings. A

list of dimensioning symbols and their meaning are shown in Fig. 2.8 [3]. Table 2.1 shows some of the standard abbreviations used on the technical drawings.

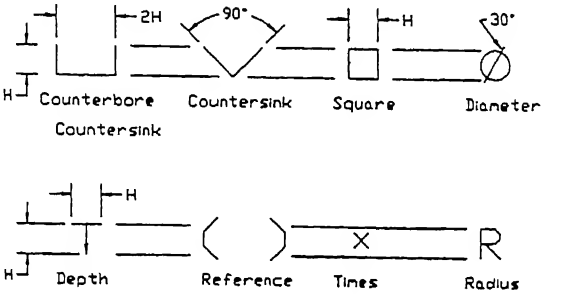


Fig. 2.8 Dimensioning symbol

Table 2.1 Some of the standard abbreviations

AL	Aluminum
C'BORE	Counterbore
CRS	Cold rolled steel
CSK	Countersink
DIA	Diameter
EQ	Equal
HEX	Hexagon
MATL	Material
R	Radius
ST	Steel
SQ	Square
REQD	Required

2.4 ANNOTATION

Control of the appearance and format of dimensions is necessary to maintain the uniformity. Dimension style determines the look of the dimensions as well as the size of the dimensioning features, such as dimension text and arrows. It also makes the work easier by allowing storing and duplicating the most common dimension settings. Within the dimension styles, dimensions are divided into "families". The dimension families are angular, diameter, linear, leader, ordinate, and radial. The parent family affects all the dimension family globally.

Setting of the dimension standards is important to maintain uniformity in the drawing generation [2]. The standard setting used are illustrated in the following sub-sections.

2.4.1 TEXT

Applying notes to the drawing is one of the major and tedious tasks. AutoCAD provides two types of text option, named single line text and multiline text. The format of the text is as follows:

- Text Style : Standard
- Text width factor : 1.0000
- Text height : 2.0000
- Justification : Left (but could be at center or right also depending on the requirement)

2.4.2 PRIME UNITS

The settings of the units for drawing generation are as:

- Units : Decimal
- Angle : Decimal degrees
- Decimal Precision : 0.0000
- Tolerance Precision : 0.0000
- Scale (linear) : 1.0000

2.4.3 GEOMETRY

Geometry is used for setting scale, arrow, etc. Line thickness, centerline, etc., must be defined and text must be scaled up in size in order to appear at the proper size in the final output of the drawing. Dimensions, too, must be scaled so they look right when the drawing is plotted. Geometry is based on the IS code.

Thickness of the drawing generated has the default value, except the outer boundary or any prominent boundaries where the width can be assumed suitably to 3.0-5.0 or the default value itself depending upon the readability and clarity of the drawing. All other lines and curves like, centerline, extension line, dimensioning line, arc, etc. must have the default value. The origin offset of the extension line is set around 1.5-2.0 mm so as to have clarity. The geometry of the arrowhead is closed filled type on both the left and right hand side. The details of the standards used in the generation of drawings are listed in Fig. A2.5 and Table A2.1 of Appendix-II.

2.5 WORKING DRAWINGS

Creating assembly drawings, part lists, and detailed drawings includes also titles, revisions, tolerances, and release blocks.

Assembly drawings show how objects fit together. Assembly drawings are sometimes called top drawings because they are the first of a series of drawings used to define a group of parts that are to be assembled together. The group of drawings is referred to as a family of drawings. The group may include sub-assemblies, modification drawings, and a part list. Assembly drawings do not contain hidden lines. A sectional view is used to show internal areas critical to the assembly. A part number identifies each part of the assembly [3].

A detail drawing is a drawing of single part and includes all the information necessary to accurately manufacture the part, including the orthographic views with all appropriate hidden lines, dimensions, tolerance, material requirements, and any special manufacturing requirements.

2.5.1 DRAWING FORMATS

Fig. A2.1, A2.2 and A2.3 in the Appendix-II shows the format generated for the A4, A3 and A2 size drawing sheets respectively. Fig. A2.6, a detail drawing of A4 size, is also included in the Appendix-II as an example [1]. The format is according to the IS standards.

2.5.2 TITLE BLOCK

Title blocks are created as per IS coding No. 11665-1985. It is located in the lower right corner of a drawing and includes the drawing's name, the company's name, the drawing scale, the release date of the drawing, and many other information.

Drawing numbers:

The company according to their usage requirement assigns drawing numbers to the part. The numbering system standard format is as *4305.8012*, i.e., after the first four digits a decimal is placed and then another four (or may be five) digits are placed.

Scale:

Scale in the drawing is represented as 1:1, meaning drawing's size is same as the object's size. If it is 2:1, it means drawing's size is twice as large as the object's size.

Release date:

A drawing is released only after all persons required by the company's policy have reviewed and added their signature to the release block. Once released, a drawing becomes a legal document.

2.5.3 REVISION BLOCK

Drawings used in industry are constantly being changed. Products are improved or corrected and drawings must be changed to reflect and document these changes. A revision block attached to the drawing template is shown in Fig. 2.9.

ISSUE	MODIFICATION	DATE	SUGGESTED BY	CHECKED BY	APPROVED BY

Fig. 2.9 Revision block attached to the drawing template

Drawing changes are listed in the revision block by letter. A brief description of the change is also included. Revisions are often used to check drawing requirements on parts manufactured before the revisions were introduced.

Most companies have systems in place that allows engineers and designers to make quick changes to drawings. These change orders are called Engineering Change Order (ECOs), Change Orders (COs), Engineering Orders (EOs), depending on the company preference. Change orders are documented on special drawing sheets that are usually stapled to a print of the drawing. After a group of change orders accumulates, they are incorporated onto the drawing. This process is called a drawing revision and is different from a revision to the drawing.

2.5.4 RELEASE BLOCK

A release block as shown in Fig. 2.10 contains a list of approval signatures or initials required before a drawing can be released for production. The required signatures are as follows.

The engineer in charge of the designer project is responsible for passing the design column. Person that created the drawing signs the drawn column. Drawings checked for errors and compliance with company procedures and drawing column

indicates conventions. Approval of the drawing is necessary before releasing for production.

DESIGN BY		
DRAWN BY		
CHECKED BY		
APPROVED BY		

Fig. 2.10 Release Block

Chapter 3

DESIGN AND DEVELOPMENT OF DATABASE FOR A VEHICLE

3.1 INTRODUCTION

A database is a collection of related data, typically organized to serve a specific purpose in an application. Data in the database can be entered, edited, and deleted. The database is stored in one or more files and is in tabular form. The same data can occur in more than one table in a given database. In the database model, a table is a two-dimensional data structure made of rows and columns [7].

- A row describes one of the elements in the table. The description is a list of attributes pertaining to the element. A row is also called as a record.
- A column specifies some aspect or attribute of the object. A column is also called as a field.
- The intersection of a particular row and column contains a single data value or attribute value.

3.2 TEMPLATE DESIGN

The use of databases in CAD drawing is by no means universal. There are additional sources of information, called bill of materials, which can be combined with the drawing to make it more powerful. There are information frequently required about a drawing, such as:

Component drawing number

Component description

How many?

Purchased or manufactured?

Material specifications

Any special features not otherwise specified

These question leads to form a standard structure for bill of materials so as to avoid redundancy, enforce standards, maintain integrity, and balance conflicting requirements. The standard structure for bill of materials is as shown in Fig. 3.1 [13].

Deciding what to store in a database is one of the first steps in designing any software system. The simplest database design is the single database. There are just two steps to designing a single database system:

1 Decide what fields to put in the database.

2 Identify key fields for sorting and searching.

Field	Field Name	Type	Width	Dec	Explanations
1	SNo	Character	3		: Serial Number
2	PART_NO	Character	10		: Part Number of the component
3	PART_NAME	Character	35		: Description of the component
4	QTY	Character	3		: Number of component required
5	SRC	Character	3		: Source, i.e., manufactured inhouse or a vendor part.
6	MTL	Character	3		: Material Specification
7	REMARKS	Character	9		: Remarks

Fig. 3.1 Structure design for bill of materials with explanation of the Field Name code.

Here an example of BOM NO. 70060 (Bill of material number 70060) is taken as a running example. A simple 70060.dbf have the database structure shown in Fig. 3.1.At the dot prompt in the dBase environment typing *create 70060* command opens structure design menu asking to fill Field heading. Once the structure is designed, as shown in Fig. 3.1, the records can be entered [13].

3.3 CREATING THE DATABASE

Data is generated in the environment of dBaseIII. It's a DOS version database management system used for managing information stored on computer. Managing a database includes adding new information, sorting, searching, printing reports, editing, and deleting data.

In order to add a record and see the list of the bill of materials the commands are as follows:

- Type *USE 70060* at the dot prompt.
- Type *APPEND* to enter new records.
- Press *Ctrl+END* to save the work done.
- Type *LIST OFF* to see the bill of materials generated.

The bill of material generated will look as in the format shown in Fig. 3.2.

BILL OF MATERIAL

SNO	PART_NO	PART_NAME	QTY	SRC	MTL	REMARKS

Fig. 3.2 Template design for bill of material

Report generation is one of the important part of database entries. Report generation means process of obtaining a hard copy of the database created. Main menu helps to generate report. *Create* option on the main menu bar has pull down menu containing option *Report.* Highlighting and selecting it asks for the drive and a file name for the report format. On entering the appropriate data dBase displays a menu of the format options for printing reports. The report once created can be retrieved any time by *Retrieve (Report)* option in the main menu. The hard copy can also be taken by submitting the request when asked while *Retrieve (Report)* command is executed. List of BOM No 70060 and its report, i.e., hard copy is shown in Fig. A1.1 and Fig. A1.2 of Appendix-I respectively. The format of the report is shown in Fig. 3.3.

PART NAME

PART NUMBER : (BOM NO :)

SNO	PART NO	PART NAME	QTY	SOURCE	MATERIAL	REMARKS

Fig. 3.3 Report format

3.4 PROGRAMMING dBASE III

dBase III has a built in text editor for creating command files. The dBase III *Modify* command word processor allows creating and editing a file; the dBase *Do* command allows to run them [12].

The programming is done in the dBase environment to move through the hierarchical structure of the bill of materials, as illustrated in Fig. 3.4. The complete

Program asks options to the user, wait for a response, and store that answer to a field of a file to try out these commands.

To make the database system more friendly and easy to use customization of the screen is important, as shown in Fig. 3.5. The user will have to do is to select an option, and the program will take over from there. Rather than attempt to write one very large program to handle the various tasks, its better to create a separate, smaller program for each individual task. This modular design makes the programming task much simpler, and the program logic much easier to follow. In modular program design, the various tasks of the software can be shown as boxes in a hierarchical structure. This allows seeing how the various parts of the system are related. Fig. 3.6 shows the modular design for database.dbf system software. In section B of Appendix-III, programming in dBase environment is illustrated. First part of the section shows the program for creating menu option for bill of material (the main program) and second part shows the program for BOM NO. 70000, which is called by the main program. There are many other sub-routines (like program for BOM NO. 70000), but only one is presented in Appendix-III for illustration.

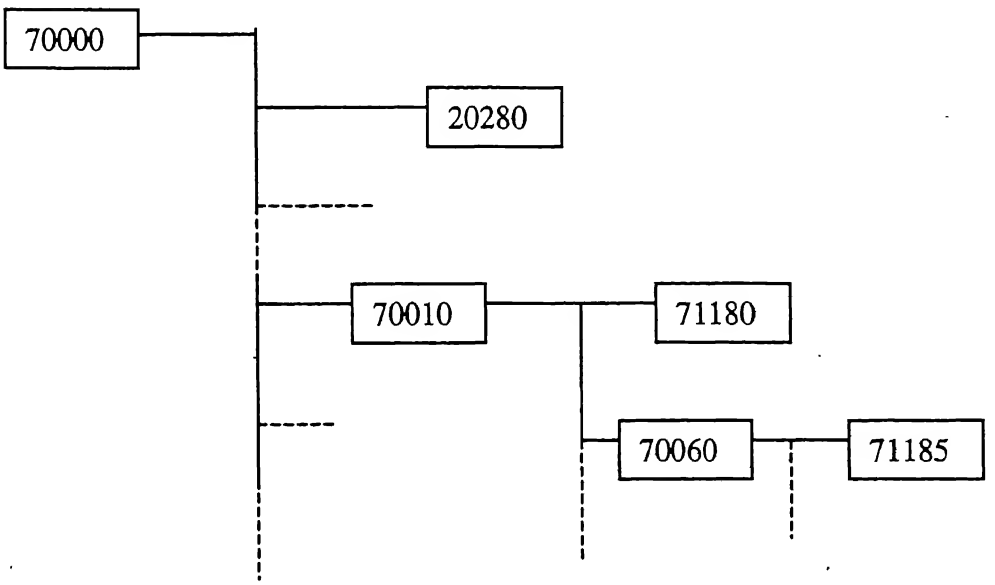


Fig. 3.4 Hierarchical structure of the BOM No. The number inside the box

DATABASE OF VIKRAM 08/18/98 01:26:14

BILL OF MATERIAL OF COMPLETE VEHICLE

1. SEE THE INDEX FILE
2. SEE THE LIST OF BOM NO 70000 (COMPLETE VEHICLE ASSEMBLY)
3. BOM NO 70000 BRANCHES INTO....
4. EXIT DATABASE

ENTER CHOICE (1-4) [ ]

Fig. 3.5 Menu option for the Bill of Material of Complete Vehicle

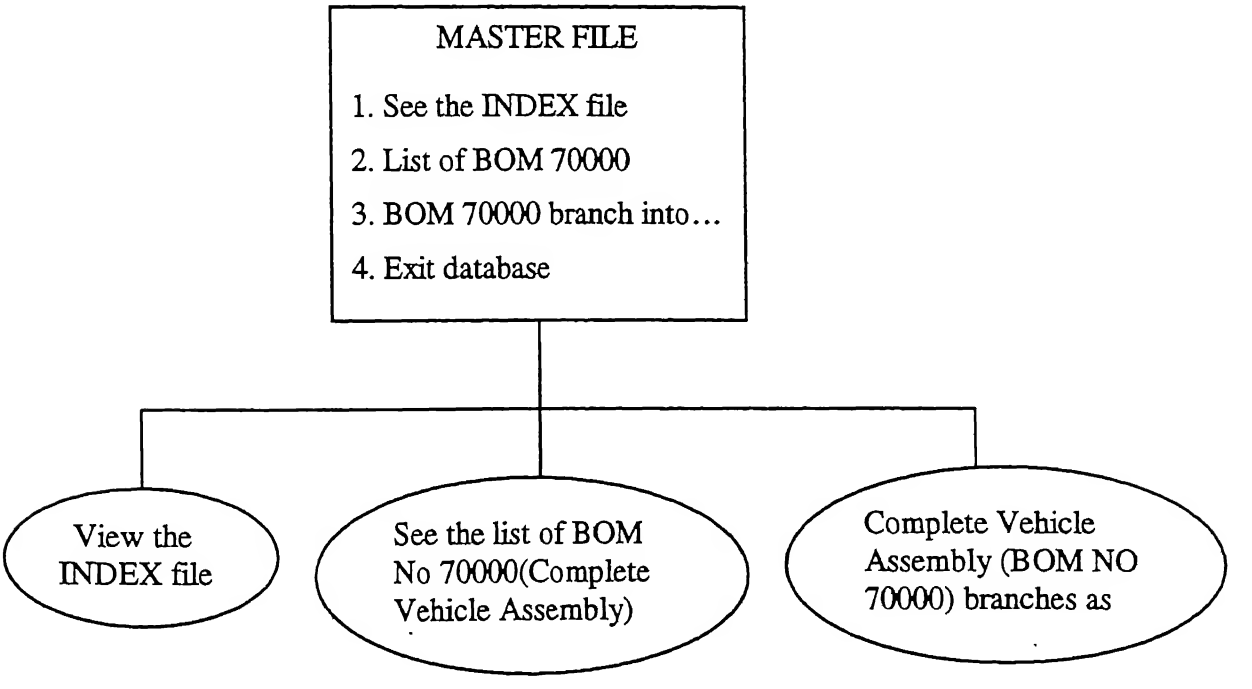


Fig. 3.6 Hierarchical structure of programs in the Database System

The first step in writing a command file is to decide what the programs needs to do, and then developing the English-like Pseudocode that provides a working outline. A database program needs to perform three main tasks:

1. Set up system "parameters".
2. Present a list of option to the user, and wait for a selection.
3. Branch to the appropriate program to perform the task the user selected.

So the pseudocode for the Database.prg command file looks something like shown in Table 3.1 [12]. Once the program is mapped out in pseudocode, the command file is written as illustrated in section B of Appendix-III. Typing *Do database* at the dot prompt gives the database main menu as shown in Fig. 3.5. Selecting an option instructs the program to take over from there.

TABLE 3.1 Pseudocode for Database.prg command file

```
Set up system parameters
Set up loop to perform tasks and then repeat menu
    Clear screen
    Present menu of option
        1. See the INDEX file
        2. See the list of BOM NO. 70000 (Complete vehicle assembly)
        3. BOM NO. 70000 branches into....
        4. Exit database
    Wait for user to select option
    Branch to appropriate program
```

If choice = 2, branch to see list of complete vehicle assembly

If choice = 3, branch to BOM 70000 contains sub-assembly....

On return to main program, redisplay menu

Quit (if user selects exit)

3.5 QUERY FACILITY

For any given search or query in a database, there are several ways to accomplish the same goal. In dBaseIII Plus every command issued is typed in as a statement – in effect, as a sentence in a language that can be thought of as a highly stylized and restricted form of written English. Query By Example (abbreviated QBE) offers a way to have a visual or picture-oriented manner of thinking [10]. The user in QBE operates by writing questions at the dot prompt in the dBaseIII Plus environment. Knowing the key field a query can be issued as:

LIST OFF FOR PART_NO = '.....'

LIST OFF FOR SRC = '.....'

Query may also contain some arguments or parenthesis, which helps refine the logic of a search [13], e.g.,

LISTOFF FOR QTY > 2 .AND. SOURCE = .I.

which means, "Display records where the quantity is greater than 2 and source is in-house".

To create a query, first the file should be open. If it is required to work with a particular record in a file then only that record can be called by issuing a query command and saved by setting it to call it repeatedly (if required).

For maximum speed in searching a database, an indexed file is opened. One of the most important factors affecting the speed of a search is the use of the FOR (Build a search condition) and WHILE (Build a scope condition) options.

A number of questions can be answered by issuing a query command as:

- *What are the name of the components whose material specification is steel?*
- *What are the components that are brought from vendors?*
- *Give the bill of material of PART_NO, say 4294.0020.*
- *What is the total quantity (in numbers) of the PART_NO, say 4294.0020?*

Chapter 4

AUTOCAD-DBMS LINKING

4.1 SQL FEATURE OF AutoCADR14

The AutoCADR14 SQL Extension (ASE) facilitates to access and manipulate non- graphic data stored in external databases. These manipulations can easily be performed directly from within AutoCADR14. ASE provides with direct access from within AutoCADR14 to external database management system (DBMS) such as dBase, INFORMIX, ORACLE, and PARADOX. ASE provides the same command regardless of the database in use. ASE application is used to manipulate data for bills of materials, asset management, estimating, or to directly access a standard parts database. It helps to establish connections between objects in the drawing and data in the database. The ASE facilitates to manipulate external data and link it to AutoCADR14 graphic entity [7].

ASE provides three features that enable AutoCAD to access data in external databases: a command set, database drivers, and a programming interface. Linking graphic entities in the drawings to external non-graphic data provides the following:

- Commands to access and manipulate data in external databases from within AutoCADR14 with or without using SQL syntax.
- Commands to create and manipulate links between non-graphic data in external databases and all graphic entities in AutoCADR14 drawings.
- Commands to view and manipulate linked non-graphic data from AutoCADR14.
- Object selection based on graphic and non-graphic data.
- Displayable attributes (text entities that display data values in linked, non-graphic databases) that can be updated automatically if data changes.

4.2 ASE Functional Overview

ASE commands provides to attach, or link, graphic entities in an AutoCADR14 drawing to a row or rows in an external database. The resulting non-graphic data is available to the DBMS even when the drawing the drawing is not loaded even when the drawing is not loaded in the AutoCADR14; the data is stored in the native external database format. The database links are stored in the AutoCADR14 drawings. Links can be modified only when the drawing containing them is loaded into AutoCADR14. The database values can, however, be changed either from within AutoCADR14 or from within AutoCADR14 or from within the DBMS. Both AutoCADR14 and the DBMS access the same data; changes made by either are reflected whether viewing the data using ASE or using the DBMS directly.

The relationship between AutoCADR14 entities and external databases is a many-to-many relationship. AutoCADR14 entity can be attached to none, one, or many rows. Fig. 4.1 shoes the relationship between ASE and DBMS drivers' [7].

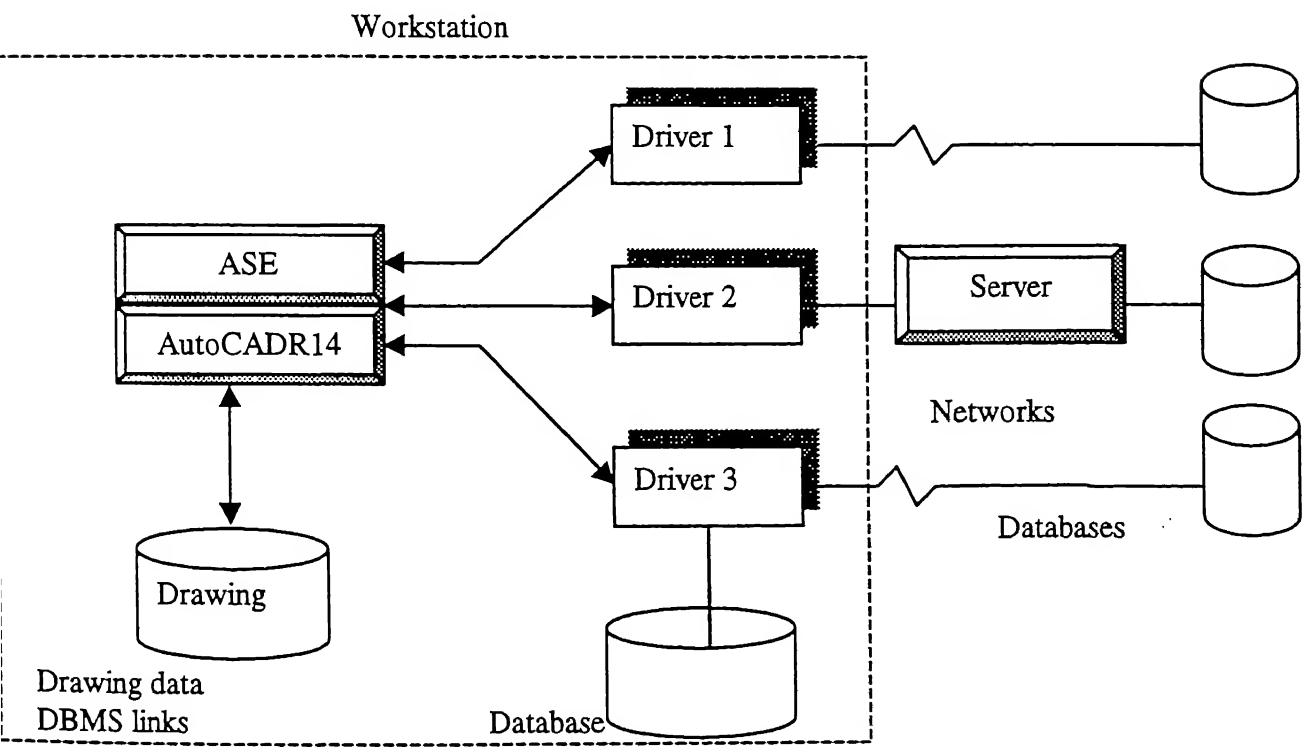


Fig. 4.1 ASE's interaction with AutoCADR14 and database drivers

Each entity in the drawing can contain many links. Each link in a drawing has an associated path describing its connection to the external database. The path contains the names of the DBMS, database, table, key columns, and key column values for the associated non-graphic data.

4.3 LINKING DBASE FOR WINDOWS WITH AutoCADR14

There are two types of database drivers supplied with AutoCAD Release 14: drivers used to directly connect to specific database applications, such as Oracle and dBase; and ODBC drivers used to connect to any database application that has a corresponding ODBC interface (Open Database Connectivity) [14]. ASE provides a set of database drivers, each of which lets us to connect to an external database. The AutoCAD SQL interface, ASI, lets to create AutoCAD-specific applications that can access external databases. In fact, the ASE command set is an application created with ASI.

Requirements for AutoCADR14 ASE and dBase for windows are follows [14]:

- AutoCAD Release 14
- Windows 95, Windows NT 3,51 or NT 4.0
- dBase for Windows
- Microsoft ODBC driver kit 3.0 (or equivalent driver by another manufacturer).

AutoCADR14 has an external database configuration editor that runs independently of AutoCAD. This editor provides a user interface for easily setting of the database configuration environment in AutoCADR14.

4.3.1 Defining Keys

When an entity is linked with data in an external database, specification of the row or rows in the database table is needed via a *key*. A *key*, in turn, specifies a column

or set of columns in the table and a value against which the column values are matched [7]. For example, if the key column is AutoCADR14 and a value of 4305.8012 is specified, the Part_No column of the table must have a value of 4305.8012 to match. The key identifies one or more rows in the specified external database to attach to the entity. A unique key matches only with one row in a table.

A key may consist of more than one column; for example, Part_No 4305.8012, Part_Name Lock nut. In this case the key is called a *compound key*.

4.3.2 Control Database

A control database stores the names of all DBMS programs, databases, and tables connected to the drawing. It also stores the information for links between drawing entities and rows in the external databases. The control database is created when ASE is initialized and is part of the drawing file. The ACADASE layer is created whenever the control database is saved. The control database is saved with the AutoCAD SAVE and END commands. ASE uses a layer named ACADASE to store the control database as part of the drawing between editing sessions.

4.3.3 Synchronization

Databases and AutoCAD *.dwg* files can become asynchronous in two-situation [7]. First, a drawing can have links connected to a record that has been deleted from the databases. Second, links can reference non-existent graphic entities.

The first situation occurs if a record is deleted from a database when the drawing to which it is attached is not loaded in AutoCADR14, or if AutoCADR14 is not loaded. AutoCADR14 is a single drawing file environment, and the database management systems are not aware of the graphics links stored in the AutoCADR14 drawing. The second situation occurs when a graphical entity is deleted prior to removing links attached to the entity.

4.4 DBASE III Plus Driver

In the dBase III Plus DBMS, subdirectories represent the logical database and dBase III Plus *.dbf* files represent the tables. An environment variable should be set. The name of this variable is an alias for the directory path which holds the *.dbf* files.

Logging on to dBase III Plus requires only a database name [7]. Username and password prompts appear, but the entries are not required. When using dBase III Plus on a UNIX operating system read, write, and search permissions should must be there on the directory where the database files reside and also read/write permissions is required on the database files.

4.5 METHODOLOGY

The methodology formulated for the development of the database for CAD is shown in Fig. 4.2 as follows:

4.6 WORKING EXAMPLE

AutoCADR14 offers high degree of flexibility and customization, allowing having a feel of software's look as per requirement. AutoCADR14, in addition to adding buttons and toolbars, also allows to add pull-down menu options. A sample of the program for pull down menu for mymenu is shown in appendix-III.

4.6.1 LOADING THE On-Screen AEC Menu

Program for generating a menubar with the name, "Mymenu" is written to run in the environment of AutoCADR14 as shown in section A of Appendix-III. This menubar displays the drawing files organized in an hierarchical manner. The drawing once selected from Mymenu menubar, gets opened in the environment of AutoCADR14. But the menubar, "Mymenu" should be loaded on the main menubar of

AutoCADR14. If it is not loaded the steps illustrated below should be followed to load it. Once it is loaded on the AutoCADR14 screen then it will come always whenever AutoCAD is opened.

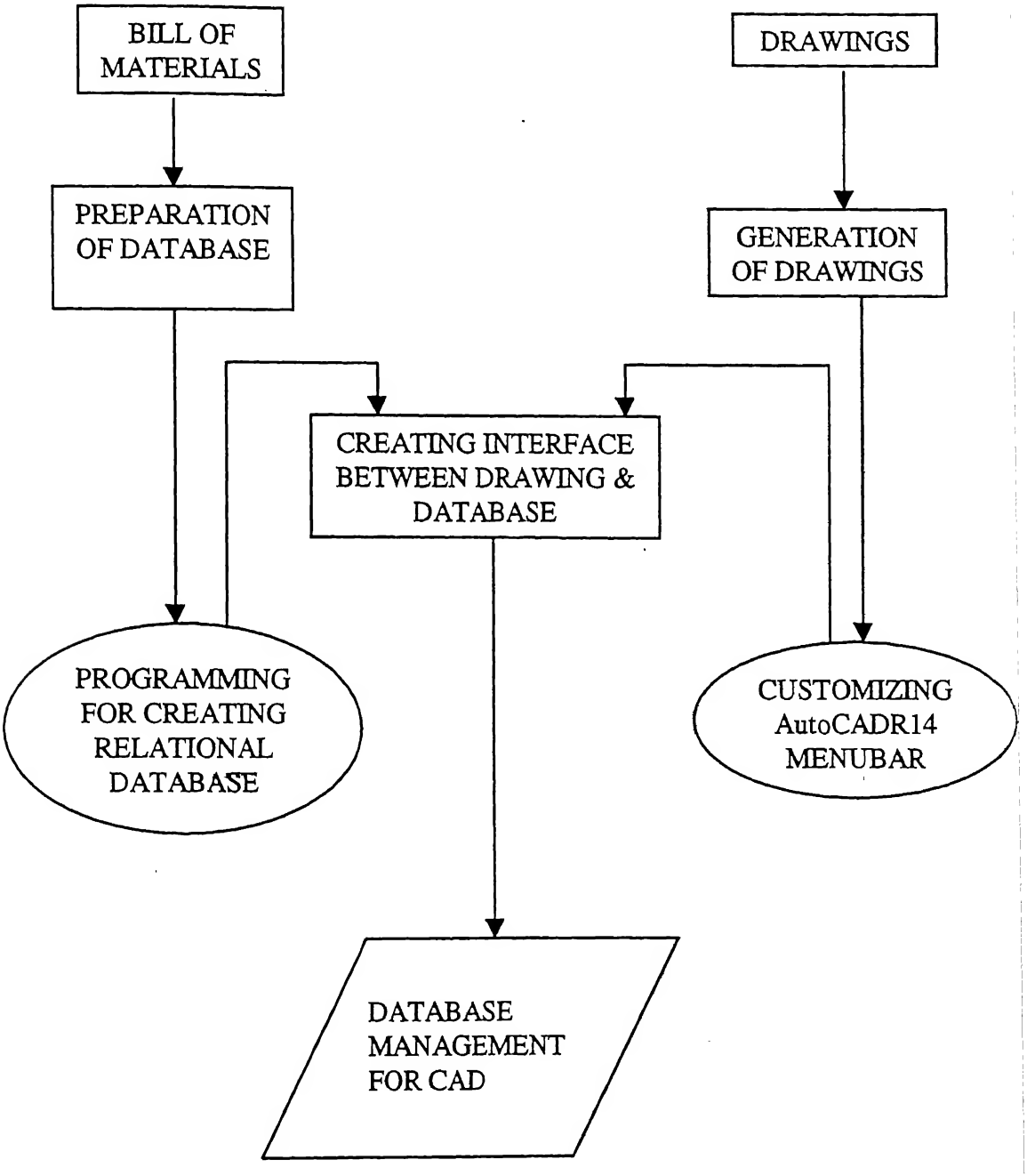


Fig. 4.2 Methodology for CAD database design

1 Choose Tools > Customize menu, or type menuload at the command prompt. The Menu customization dialog box appears as shown in Fig. 4.3 (a).

2 Clicking on the Browse button at the bottom of the dialog box opens the select Menu file dialog box.

3 Selecting the file name *mymenu.mnu* opens the Menu customization dialogue box and the file name *mymenu.mnu* appears in the file name input box.

4 Selecting the Load button just above the Browse button in the file dialogue box loads the file.

5 In the Menu groups list box in the upper portion of the dialogue box, highlight mymenu.mnu file, and selecting the menu bar tab at the top of the dialogue box opens the menu bar tab option as in Fig. 4.3 (b).

6 In the Menu bar list box to the right side, select the entity where to place the mymenu pull-down menu in the menu bar.

7 Selecting the insert button places mymenu in the AutoCADR14 menubar at the top of the AutoCADR14 window.

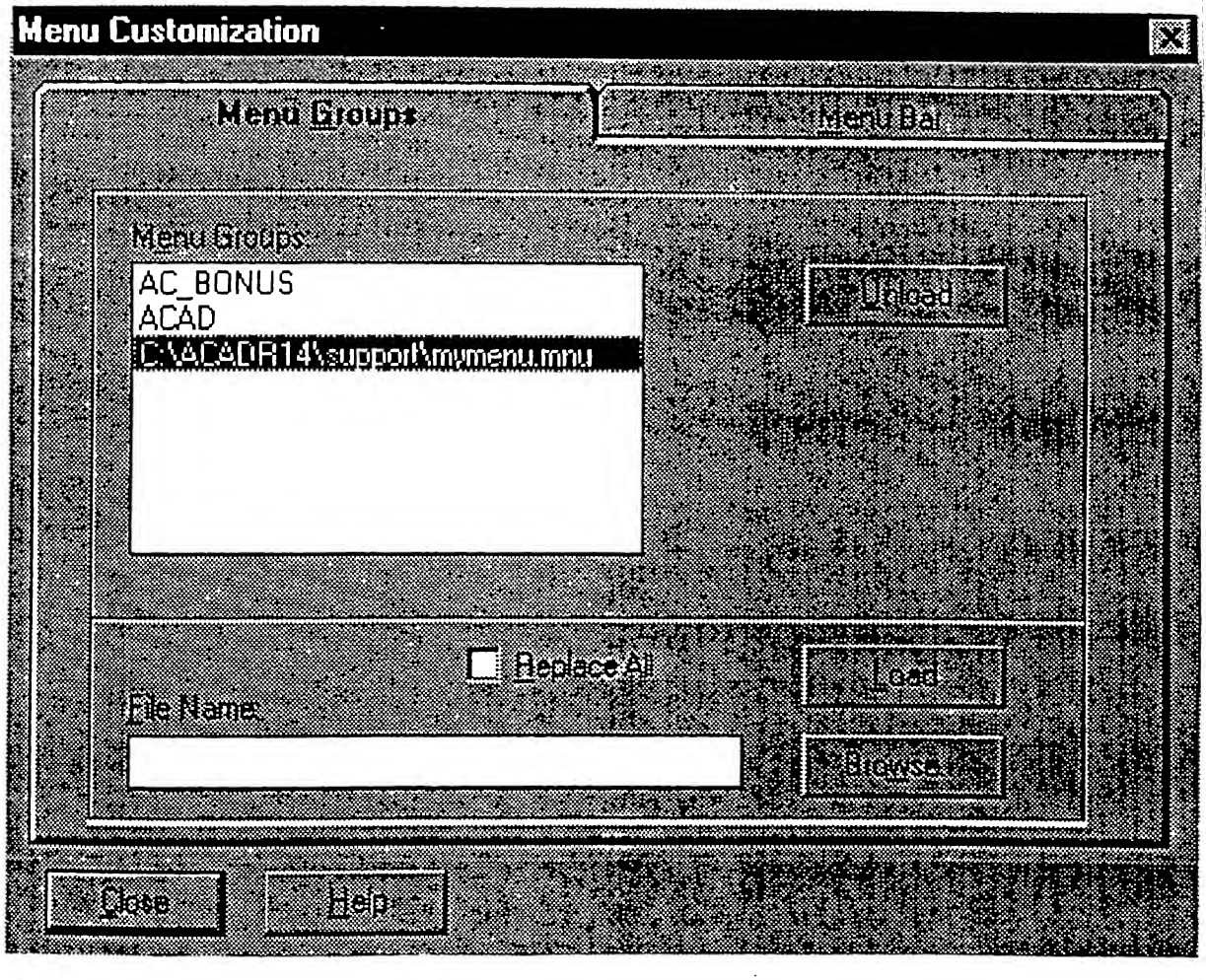
4.6.2 Opening a DATABASE from AutoCADR14

The goal of linking database (bill of materials) with the corresponding drawing is to archive it immediately whenever required along with the drawing. But the bill of material can be archived only when the environment created for linking the drawing and database is in working mode. To connect the environment the following procedures should be followed:

1. Open a drawing from the pull down menu in the mymenu toolbar by double clicking the required drawing number as in Fig. 4.3 (c).
2. On selecting the Administrator button on the external database toolbar Administration dialogue box opens as shown in Fig. 4.3 (d).
3. Highlight the Rear_Axle from the database object list. The Environment button automatically gets selected.

4. Click on the Connect button to the right of the list. The Connect to Environment dialogue box appears.
5. Because the username and password are not required so select OK.
6. Click on the Catalogue button in the database object selection group, and then click on CAT, which appears in the Database Objects list.
7. Click on the Schema button, and then click on CATFILES from the list.
8. Click on the Table button, and then click on Rear_Axl from the list.
9. Finally, click on OK to get linked to the Rear_Axl.dbf file.

The database is now in the accessible mode from within AutoCADR14. The data can now be searched, read, updated and scrolled from within AutoCADR14. For searching the



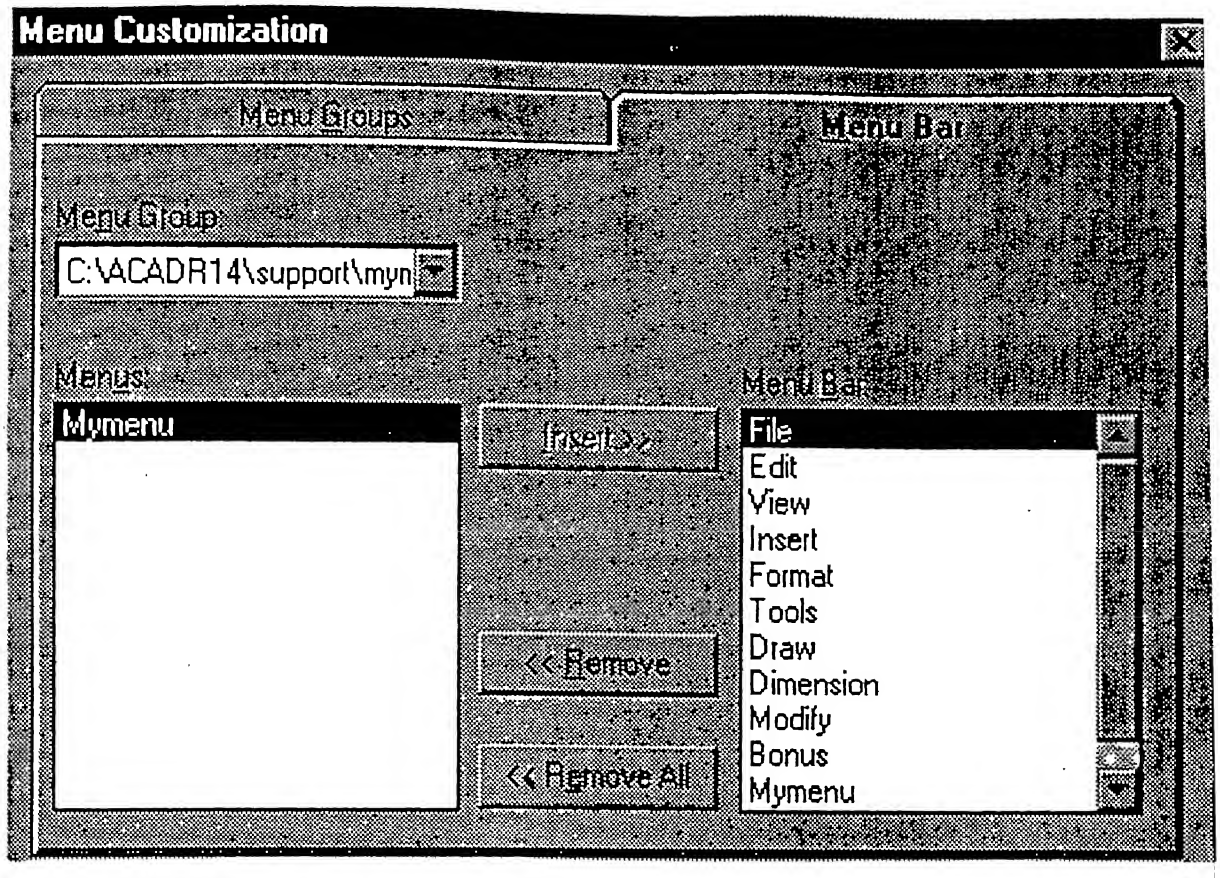


Fig. 4.3(b) Menu customization dialogue box

Row dialogue box is opened first from the external database toolbar and then the search condition be put in the Condition input box. Values of type character (CHAR) in a search string must be enclosed in single quotation marks as:

PART_NO='4305.8012'

A link is already generated and established. So to open the bill of material associated with a drawing the following procedure should be followed:

1. First open the drawing from mymenu pull down menu bar as shown in Fig. 4.3 (c).
2. Open the Rows dialogue box as in Fig. 4.3 (e).
3. Click on graphical button of the Row dialogue box. The Row dialogue box disappears momentarily allowing for selection of the linked data.
4. Select the Part_No in the drawing. The Rows dialogue box reappears showing the bill of material.

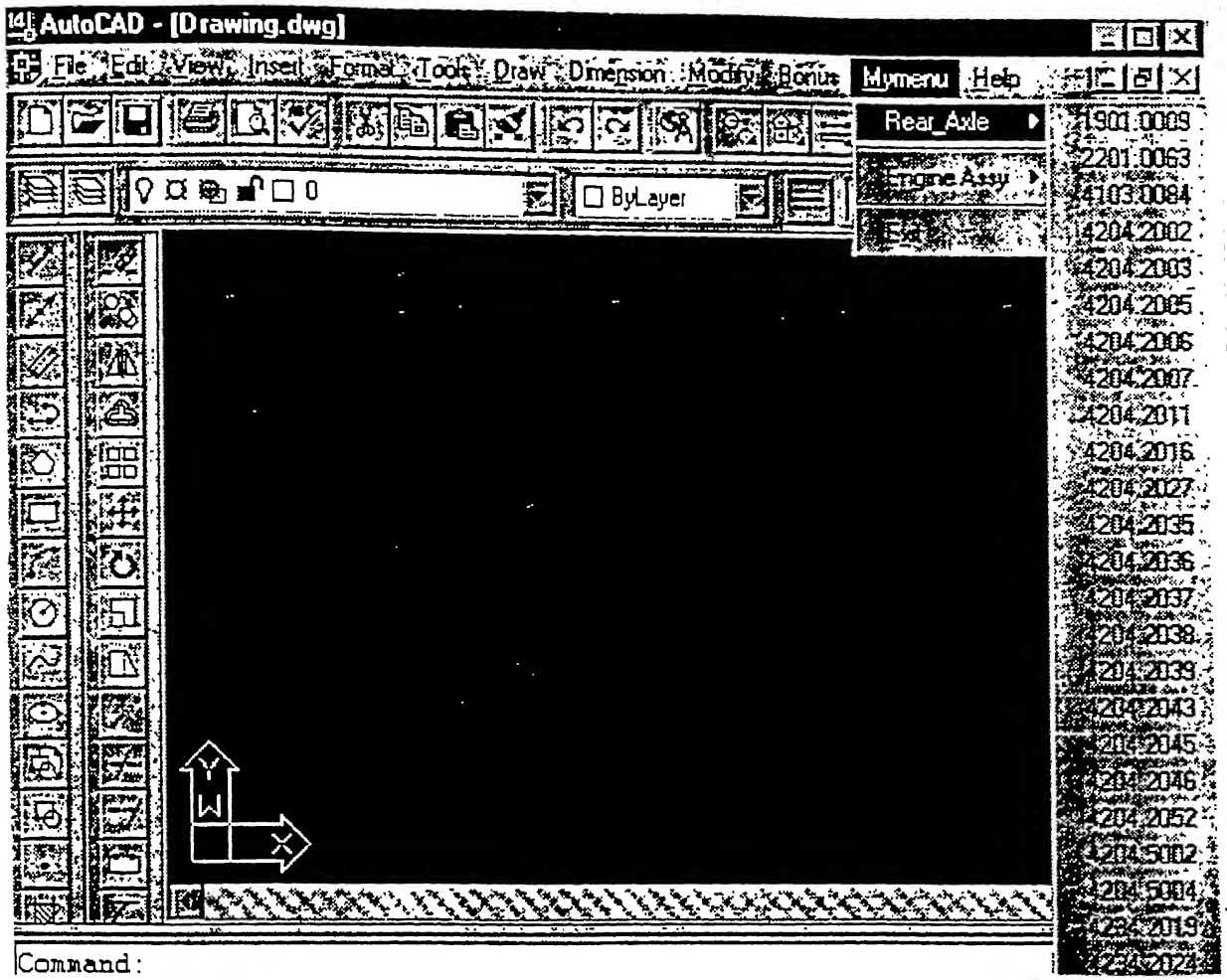
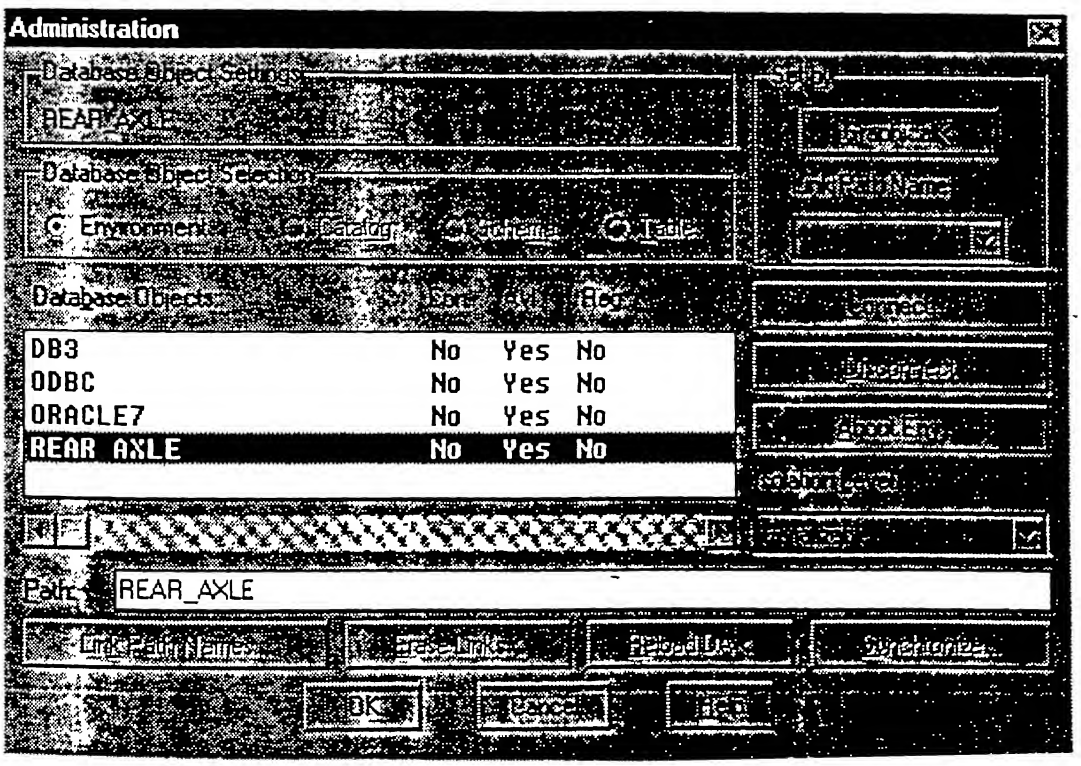


Fig. 4.3(c) AutoCAD main menubar



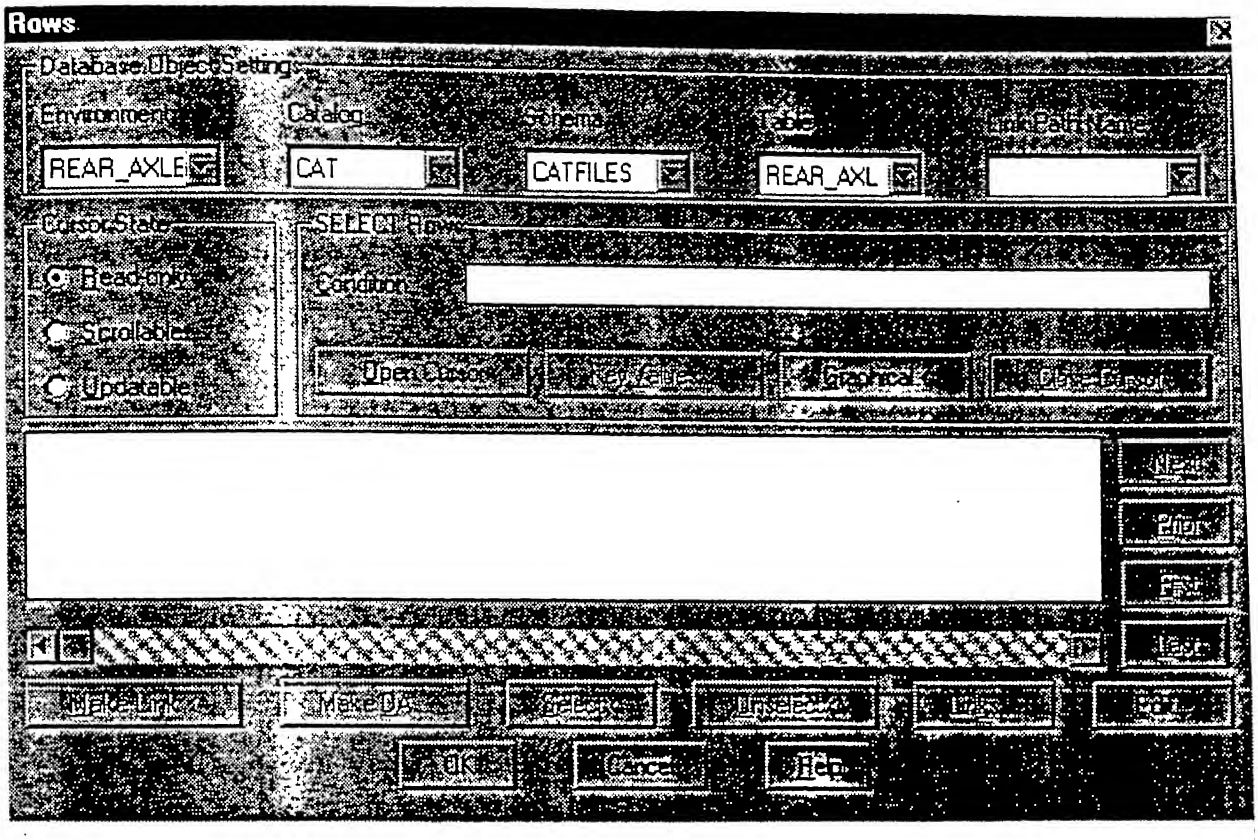


Fig. 4.3(e) Rows dialogue box

Chapter 5

CONCLUSIONS

5.1 TECHNICAL SUMMARY

Errors are unavoidable while generating drawings by hand, in terms of say line thickness, arrow size, font size, etc., even though there is a set standard. But Computer Aided Design & Drafting can minimize it. On studying and analyzing the problem of the industry AutoCAD was found suitable for the generation of drawing, supporting external database, and many other requirements.

In the present work a methodology is formulated and developed for the generation of drawing, designing of bill of materials, and establishing an environment to have link between the two.

Standardization of the methodology is a tough task and is an important step in the generation of drawing from industry point of view because drawing is the heart of an industry and has got many activities attached to it some of which is shown in Fig. 5.1. ABC analysis of the drawing is done to categorize the drawing as easy, tough, tougher... in terms of the complication of the drawing, assembly drawing, sub-assembly drawing, approximate time it requires for generation, detail drawing it requires for generation, etc. A complete overview of the tree structure of the drawing file is essential to reach the root, i.e. assembly drawing from the leaves, i.e. detail drawings.

A structure is designed for the bill of material as per the need of the industry. Bill of material provides detail about a drawing and is frequently required in the industry to look after the component description, material specifications, process the

component undergoes, component source i.e., manufactured in-house or purchased, etc. Standardization of the structure of the bill of material is done to avoid redundancy, maintain integrity and balance the conflicting requirements. A complete database is also generated with the key column set as the Part_No.

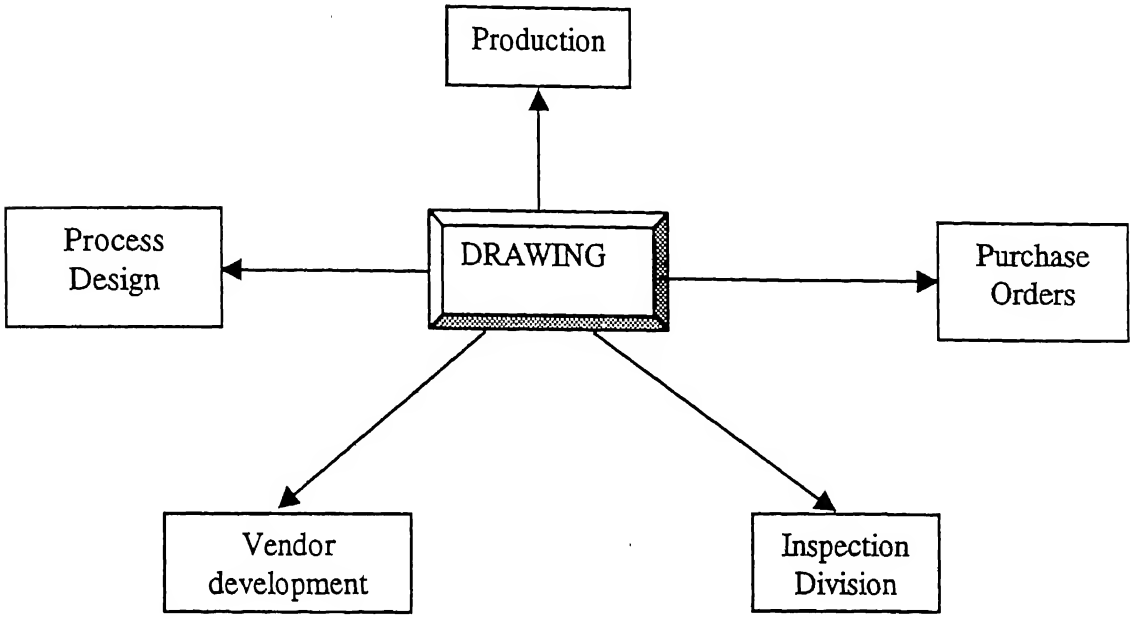


Fig. 5.1 Activities attached to a drawing

The drawing generated is linked with the associated bill of material in the environment of AutoCAD. This is done in order to facilitate the designer, purchaser, inspector, and many other persons in the industry to carry out their work in an easier way saving lot of their time. The link established is via the Part_No, i.e. the non-graphic entity that is linked in the drawing to the database is the Part_No. The other graphic or non-graphic part can also be made as an entity for linking if required.

The methodology developed is unidirectional in nature, i.e., the linked database to the drawing can be viewed in the environment of AutoCAD but drawings which is linked to the database cannot be viewed in the dBase III Plus environment. The reason being dBase is a DOS based package and AutoCAD is window based package. The bill of materials, which is generated in the dbase environment, can be called in the

AutoCAD environment and can be edited and changed there also. The changes which is made in the bill of material in the environment of AutoCAD, is also available for dBase environment, means, if the same bill of material is opened in the dbase environment the records it display is the changed one. Concluding, the linking is unidirectional in nature.

5.2 SUGGETIONS FOR FUTURE WORK

The present work is concerned with the standardization of methodology for generation of drawing, design & development of database for bill of materials and linking the drawing generated with the corresponding bill of material. The methodology developed is unidirectional in nature. The database design for CAD can be made more users friendly and flexible by incorporating the following points:

- Development of bi-directional feature of the database design, means, drawings can be archived from the environment used for generating database and vice-versa.
- Extra queries like, details of vendor (if the component is purchased), price of the component (for planning), off-loaded components, etc. can also be implemented if required by the industry.
- Customizing the menubar in the AutoCAD environment is can be done to make it more users friendly.

To meet the bi-directional nature of the project the package used for the development of database should be window based. The Oracle is a good package to be used. The query facility in Oracle is much more users friendly than dBaseIII because it is window based and dBaseIII is DOS based package. Moreover, Oracle supports the SQL (Structured Query Language) language which AutoCAD environment also supports. Oracle Application Release 11 goes beyond the traditional task of automating enterprise business process to put information in the hands of decision-makers.

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APPENDIX - I

DATABASE SAMPLE

SNO	PART_NO	PART_NAME	QTY	SRC	MTL	REMARKS
1	4351.7011	Pulley	1	E		
2	4301.7250	Dynastarter	1	E		
3	7317.2060	Washer	1	E		
4	7485.4002	Key	1	E		
5	8208.7016	Nut	1	E		
6	4358.2130	Earth Wire	1	E		
		OR				
7	4411.7240	Dynastarter	1	E		
8	4358.2130	Earth Wire	1	E		

Fig. A1.1 List of BOM NO. 70060

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08/30/98

DYNASTARTER ASSEMBLY

PART NUMBER : 4410.0618 (BOM NO : 70060)

SNo	PART NO	PART NAME	QTY	SOURCE	MATERIAL	REMARI
1	4351.7011	Pulley	1	E		
2	4301.7250	Dynastarter	1	E		
3	7317.2060	Washer	1	E		
4	7485.4002	Key	1	E		
5	8208.7016	Nut	1	E		
6	4358.2130	Earth Wire	1	E		
		OR				
7	4411.7240	Dynastarter	1	E		
8	4358.2130	Earth Wire	1	E		

Fig. A1.2 Report of BOM NO. 70060

B.O.M. Vikram 750D

Fig. A1.3 Hierarchical structure of bill of material

70000	70010	70060			
		71100			
		72320			
		72360			
		72380	73030		
		72385			
		71180	71185	***	
		72370			
	20280	***			
	70610	71890			
		20640	***		
	70290	70610	71890		
			20640	***	
		20620	***		
	70650				
	70420				
	70620	71740			
	70550	21720	***		
	70590	70510			
	70570				
	70560				
	70580	20780	***		
	70740				
	70440				
	70640				
	70410				
	70500	70220	***		

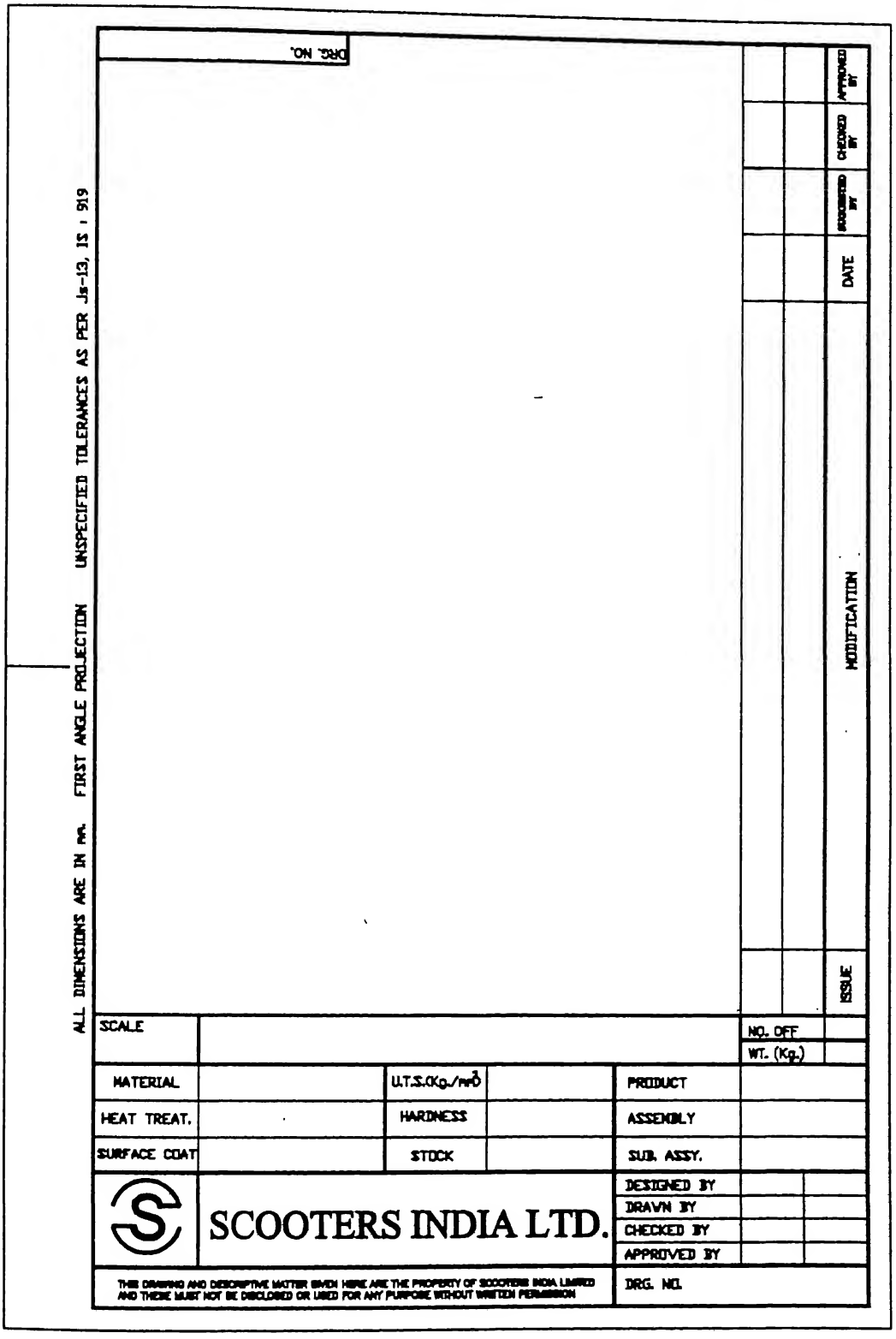
		20420	***		
		21900	***		
		20520			
	70630				
	70450				
	70460	21530	***		
		20700			
		20670	***		
		21140	***		
		20680	***		
		21150	***		
		73040			
		73050			
	70730				
	70430				
	72400	***			
	70040	***			
	70530	70540			
		70520			
		71300			
		71340	72350	***	
		71370	21330	***	
			21400	***	
			21410	***	
			21440	***	
			21450	***	
		21040	***		
		72240	72140		
		72260			
		21460	***		

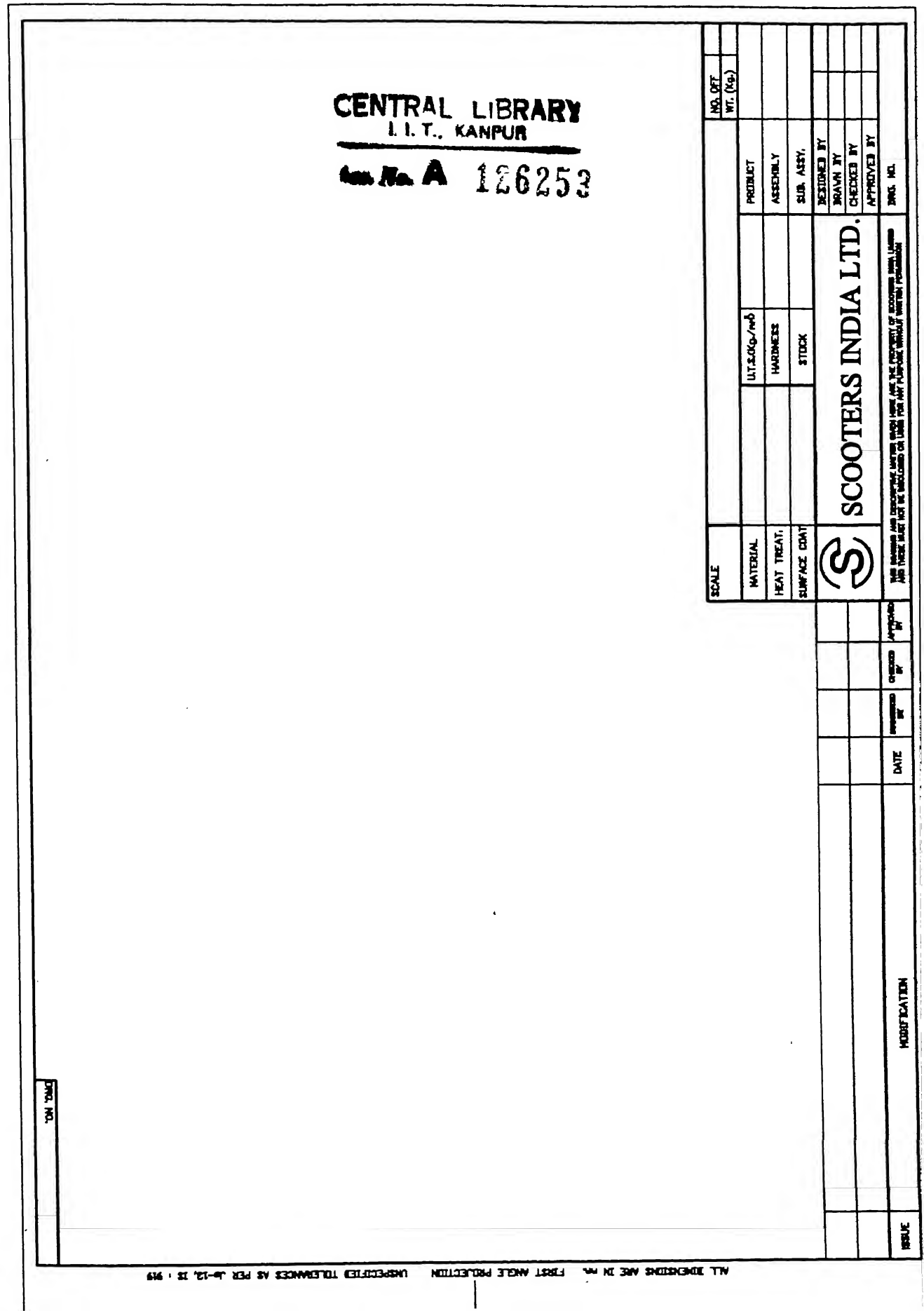
		21320	***		
		21360	***		
	71850				
	73000				
	21780	***			
	70465	70475			
	70470	70485			
	21020	***			
	61600	***			
	71700				
	73060	***			

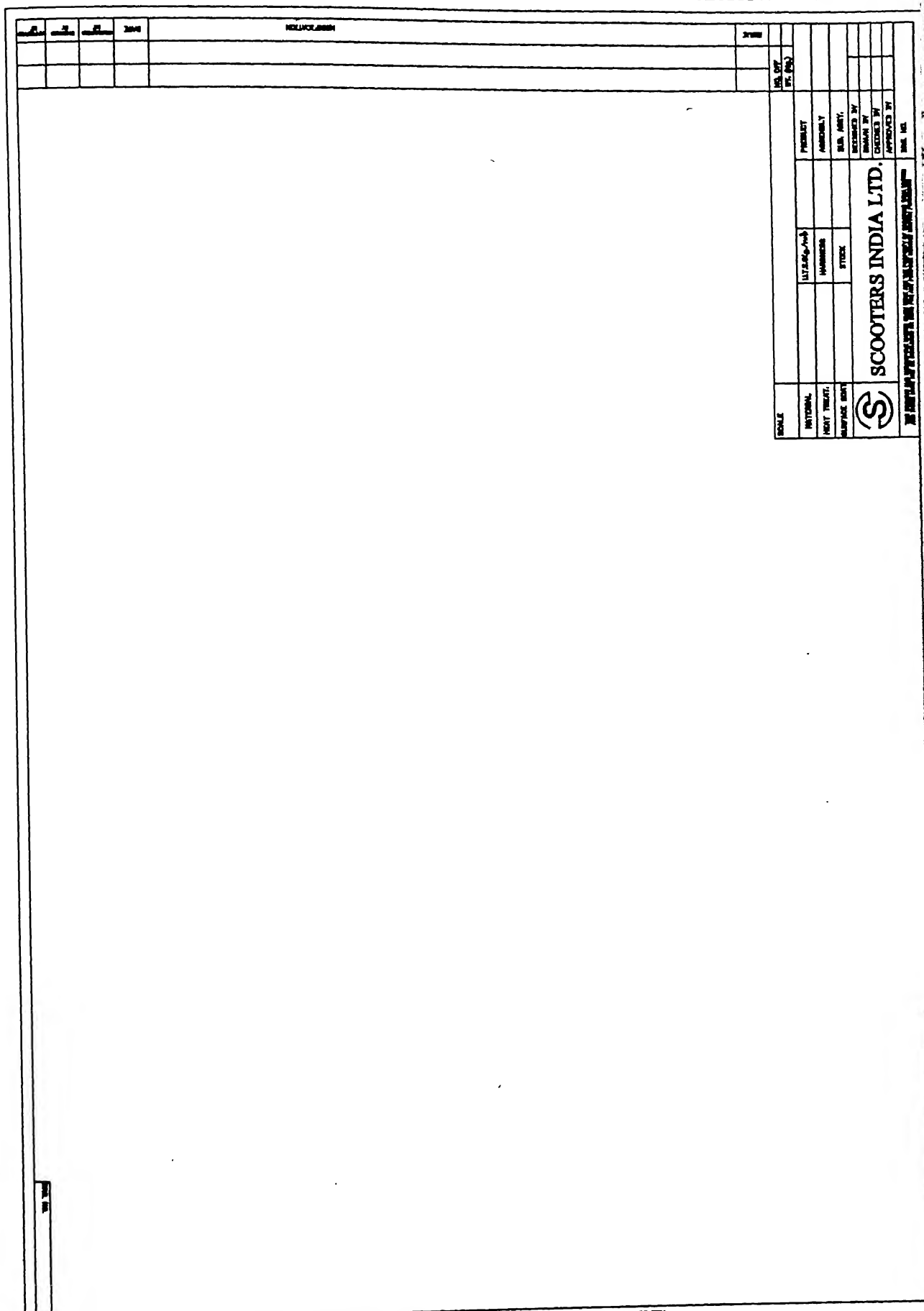
Note: In Fig. 3, * indicates that the records are not given by SIL (Scooter's India Ltd.)**

APPENDIX - II

TEMPLATE DESIGN & STANDARD






SCOOTERS INDIA LTD.

ALL DIMENSIONS ARE IN mm. FIRST ANGLE PROJECTION UNSPECIFIED TOLERANCES AS PER Js-13, IS : 919

ALL DIMENSIONS ARE IN mm. FIRST ANGLE PROJECTION UNSPECIFIED TOLERANCES AS PER Js-13, IS : 919

Part number (1)(b) DRG. NO.

(7) Drawing

(6) Text/Notes attached to the drawing.

ISSUE	MODIFICATION	DATE		CHECKED BY	APPROVED BY

SCALE (3)	(2) Part Name	NO. OFF	
		WT. (Kg.)	

MATERIAL	(4)	U.T.S.(Kg./mm²)	(5)	PRODUCT	(5)
HEAT TREAT.	(4)	HARDNESS	(5)	ASSEMBLY	(5)
SURFACE COAT	(4)	STOCK	(5)	SUB. ASSY.	(5)

SCOOTERS INDIA LTD.

DESIGNED BY		
DRAWN BY		
CHECKED BY		
APPROVED BY		

DRG. NO. (1)(a) Part Number

NUMBER	STYLE	TEXT HEIGHT	WIDTH FACTOR	JUSTIFY	ROTATION	LINE THICKNES
1 (a)	Standard	4	1.5	Default	0 degree	Default
1 (b)	Standard	4	1.5	Default	180 degree	Default
2	Standard	4	Default	Middle Center	0 degree	Default
3	Standard	4	1	Default	0 degree	Default
4	Standard	2	Default	Middle Center	0 degree	Default
5	Standard	2	Default	Middle Center	0 degree	Default
6	Standard	2	1	Left Justified	0 degree	Default
7	Standard					Suitably taker

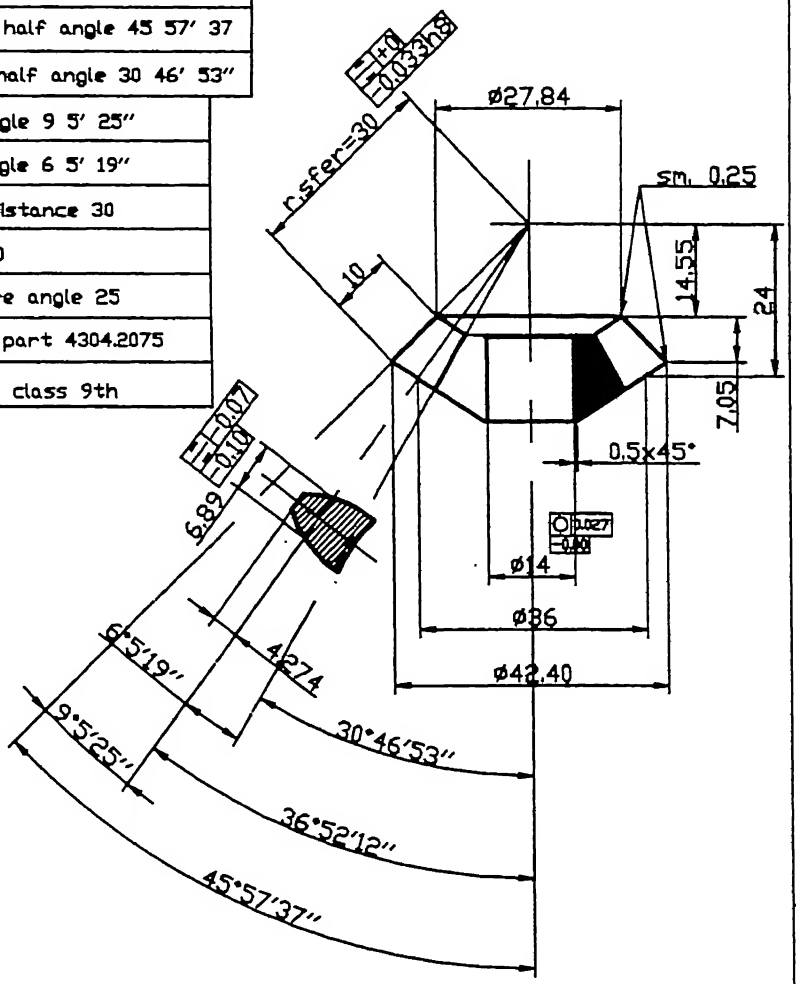
Table A2.1 Table showing the standards used to generate drawings in AutoCAD environment on A4, A3 & A2 size template

NOTE : Refer Fig. A2.5 for detail of the number in the column "NUMBER" in the above table.

DRG. NO. 4304.2074

No of teeths	9
Module	4
Pitch Dia	36
Outer Dia	42.40
Addendum	4
Dedendum	3.20
Tooth Depth	7.20
Pitch cone half angle	36 52'12"
Outer cone half angle	45 57' 37
Inner cone half angle	30 46' 53"
Addendum angle	9 5' 25"
Dedendum angle	6 5' 19"
Pitch cone distance	30
Axle angle	90
Tool pressure angle	25
Engage with part	4304.2075
Gear Quality class	9th

Notes.
1. Fillet radius recomended at the base of teeth is 0.5mm.
2. Party's identification mark is to be prominently punched on component.



ALL DIMENSIONS ARE IN mm. FIRST ANGLE PROJECTION UNSPECIFIED TOLERANCES AS PER Js-13, IS : 919

ISSUE	DATE	APPROVED BY	CHECKED BY	SUGGESTED BY
a	5-10-93: PARTY CODE ADDED			
b	23-11-90: ALT MAT: 15Ni 2Cr 1Mo ADDED			

MODIFICATION

SCALE 1:1	SATELITE GEAR			NO. OFF	2
				WT. (Kg.)	
MATERIAL	EN 354/EN36B/EN 353	U.T.S.(Kg./mm²)		PRODUCT	
HEAT TREAT.	Case Hardenning/Carbo-	HARDNESS	R 125 - 155	ASSEMBLY	
SURFACE COAT		STOCK		SUB. ASSY.	

SCOOTERS INDIA LTD.

DESIGNED BY	
DRAWN BY	
CHECKED BY	
APPROVED BY	

DRG. NO. 4304.2074

APPENDIX - III

PROGRAMS

A. PROGRMMIG IN AutoCAD ENVIRONMENT

PROGRAM FOR CREATING MENUBAR WITH NAME "MYMENU"

```
//  Begin AutoCAD Digitizer Button Menus
//
***BUTTONS1
// Simple + button
// if a grip is hot bring up the Grips Cursor Menu (POP 17), else send a carriage return
$M=$(if,$(eq,$(substr,$(getvar,cmdnames),1,5),GRIP_),$P0=ACAD.GRIPS $P0=*);
$P0=SNAP $p0=*
^C^C
^B
^O
^G
^D
^E
^T

***BUTTONS2
// Shift + button
$P0=SNAP $p0=*

***BUTTONS3
// Control + button

***BUTTONS4
// Control + shift + button

//
//  Begin System Pointing Device Menus
//
***AUX1
// Simple button
// if a grip is hot bring up the Grips Cursor Menu (POP 17), else send a carriage return
$M=$(if,$(eq,$(substr,$(getvar,cmdnames),1,5),GRIP_),$P0=ACAD.GRIPS $P0=*);
$P0=SNAP $p0=*
^C^C
^B
^O
^G
^D
```

```
***AUX2
// Shift + button

$P0=SNAP $p0=*
$P0=SNAP $p0=*

***AUX3
// Control + button
$P0=SNAP $p0=*

***AUX4
// Control + shift + button
$P0=SNAP $p0=*

//
//  Begin AutoCAD Pull-down Menus
//
***POP1
**MYMENU

ID_MnFile   [&Mymenu]
        [->Rear_Axle]

ID_Open     [1901.0009]^C^C_open c:/acadr14/dwg/1901.0009
        [2201.0063]^C^C_open c:/acadr14/dwg/2201.0063
        [4103.0084]^C^C_open c:/acadr14/dwg/4103.0084
        [4204.2002]^C^C_open c:/acadr14/dwg/4204.2002
        [4204.2003]^C^C_open c:/acadr14/dwg/4204.2003
        [4204.2005]^C^C_open c:/acadr14/dwg/4204.2005
        [4204.2006]^C^C_open c:/acadr14/dwg/4204.2006
        [4204.2007]^C^C_open c:/acadr14/dwg/4204.2007
        [4204.2011]^C^C_open c:/acadr14/dwg/4204.2011
        [4204.2016]^C^C_open c:/acadr14/dwg/4204.2016

        [4204.2027]^C^C_open c:/acadr14/dwg/4204.2027
        [4204.2035]^C^C_open c:/acadr14/dwg/4204.2035
        [4204.2036]^C^C_open c:/acadr14/dwg/4204.2036
        [4204.2037]^C^C_open c:/acadr14/dwg/4204.2037
        [4204.2038]^C^C_open c:/acadr14/dwg/4204.2038
        [4204.2039]^C^C_open c:/acadr14/dwg/4204.2039
        [4204.2043]^C^C_open c:/acadr14/dwg/4204.2043
        [4204.2045]^C^C_open c:/acadr14/dwg/4204.2045
        [4204.2046]^C^C_open c:/acadr14/dwg/4204.2046

        [4204.2052]^C^C_open c:/acadr14/dwg/4204.2052
        [4204.5002]^C^C_open c:/acadr14/dwg/4204.5002
        [4204.5004]^C^C_open c:/acadr14/dwg/4204.5004
        [4234.2019]^C^C_open c:/acadr14/dwg/4234.2019
```

```
        [--]

        [->&More]

        [4204.2057]^C^C_open c:/acadr14/dwg/4234.2057
        [4234.4003]^C^C_open c:/acadr14/dwg/4234.4003
        [4294.2048]^C^C_open c:/acadr14/dwg/4294.2048

        [4294.2049]^C^C_open c:/acadr14/dwg/4294.2049
        [4294.2067]^C^C_open c:/acadr14/dwg/4294.2067
        [4304.2074]^C^C_open c:/acadr14/dwg/4304.2074

        [4344.2023]^C^C_open c:/acadr14/dwg/4344.2023
        [4414.2033]^C^C_open c:/acadr14/dwg/4414.2033
        [4414.2034]^C^C_open c:/acadr14/dwg/4414.2034
        [8303.0300]^C^C_open c:/acadr14/dwg/8303.0300
        [8310.0010]^C^C_open c:/acadr14/dwg/8310.0010

        [8601.1622]^C^C_open c:/acadr14/dwg/8601.1622
        [<-<-7325.00040]^C^C_open c:/acadr14/dwg/7325.00040


        [--]

        [->Engine Assy]
        [<-.....]

        [--]

ID_Quit     [E&xit]^C^C_quit


***ACCELERATORS

// Toggle PICKADD
[CONTROL+"K"]$M=$(if,$(and,$(getvar,pickadd),1),'_pickadd 0,'_pickadd 1)
// Toggle Orthomode
[CONTROL+"L"]^O
// Next Viewport
[CONTROL+"R"]^V
// ID_Spell    ["\"F7\""]
// ID_PanRealti ["\"F11\""]
// ID_ZoomRealt ["\"F12\""]
ID_Copyclip  [CONTROL+"C"]
ID_New       [CONTROL+"N"]
ID_Open      [CONTROL+"O"]
```

B. PROGRAMMING IN dBASE ENVIRONMENT

(i). PROGRAM FOR MAIN MENU

PROGRAM FOR CREATING MENU OPTION FOR BILL OF MATERIAL

```
*
**********************************************DATABASE.PRG
*
* MAIN MENU FOR DATABASE
*

SET TALK OFF
SET HELP OFF
SET BELL OFF

*-------------------CREATE UNDERLINE VARIABLE, ULine.

ULine = "__________"
DO WHILE LEN(ULine)<50
    ULine = ULine +ULine
ENDDO

*--------------------DISPLAY MENU & GET USER'S CHOICE.

CHOICE = 0
DO WHILE CHOICE # 4
 CLEAR
 @ 2,1 SAY "DATABASE OF VIKRAM"
 @ 2,58 SAY DTOC(DATE()) + "     " + TIME()
 @ 3,0 SAY ULine
 ?
 ?
 TEXT
          BILL OF MATERIAL OF COMPLETE VECHILE
          ------------------------------------------


            1. SEE THE INDEX FILE
            2. SEE THE LIST OF BOM NO 70000
              (COMPLETE VECHILE ASSEMBLY)
            3. BOM NO 70000 BRANCHES INTO...
            4. EXIT DATABASE

 ENDTEXT
 @ 24,1 SAY "ENTER CHOICE (1-4)" GET CHOICE;
 PICTURE "9" RANGE 1,4
```

```
  CASE CHOICE = 1
      USE INDEX.DBF
      BROWSE

  CASE CHOICE = 2
      USE 70000.DBF
      BROWSE

  CASE CHOICE = 3
      DO 70000.PRG

ENDCASE
ENDDO (WHILE CHOICE # 4)

USE
CLEAR
*QUIT
```

(ii). PROGRAM FOR BOM NO 70000

```
**************************************************70000.PRG
*
* MAIN MENU
*

SET TALK OFF
SET HELP OFF
SET BELL OFF

*-----------------CREAT UNDERLINE VARIABLE, ULine.

ULine = "__________"
DO WHILE LEN(ULine) < 50
  ULine = ULine + ULine
ENDDO

*-----------------TEXT

CHOICE = 0
DO WHILE CHOICE # 4
 CLEAR
 @ 2,1 SAY "DATABASE OF VIKRAM"
 @ 2,58 SAY DTOC(DATE()) + "     " + TIME()
 @ 3,0 SAY ULine
 ?
 TEXT
              BOM NO 70000 BRANCHES INTO...
              ------------------------------------
 ENDTEXT
 @ 11,1 SAY "20280"
 @ 12,1 SAY "21020"
 @ 13,1 SAY "21780"
 @ 14,1 SAY "61600"
 @ 15,1 SAY "70010"
 @ 16,1 SAY "70040"
 @ 17,1 SAY "70290"
 @ 18,1 SAY "70410"
 @ 19,1 SAY "70420"
 @ 11,20 SAY "70430"
 @ 12,20 SAY "70440"
 @ 13,20 SAY "70450"
 @ 14,20 SAY "70460"
 @ 15,20 SAY "70465"
 @ 16,20 SAY "70470"
 @ 17,20 SAY "70500"
```

```
@ 11,40 SAY "70560"
@ 12,40 SAY "70570"
@ 13,40 SAY "70580"
@ 14,40 SAY "70590"
@ 15,40 SAY "70610"
@ 16,40 SAY "70620"
@ 17,40 SAY "70630"
@ 18,40 SAY "70640"
@ 19,40 SAY "70650"
@ 11,60 SAY "70730"
@ 12,60 SAY "70740"
@ 13,60 SAY "71700"
@ 14,60 SAY "71850"
@ 15,60 SAY "72400"
@ 16,60 SAY "73000"
@ 17,60 SAY "73060"

 ?
 ?
 ?
 ?
*----------------------GET LIST OF REQUIRED BOM NO.

TEXT
ENTER "4" TO EXIT THE LIST
ENDTEXT

   @24,1 SAY "ENTER CHOICE (BOM NO) " GET CHOICE;
   PICTURE "99999"
READ

DO CASE

   CASE CHOICE = 20280
      DO 20280

    CASE CHOICE = 21020
      DO 21020

    CASE CHOICE = 21780
      D0 21780

    CASE CHOICE = 61600
      DO 61600

    CASE CHOICE = 70010
      DO 70010
```

```
CASE CHOICE = 70040
  DO 70040

CASE CHOICE = 70290
  DO 70290

CASE CHOICE = 70410
  DO 70410

CASE CHOICE = 70420
  DO 70420

CASE CHOICE = 70430
  DO 70430

CASE CHOICE = 70440
  DO 70440

CASE CHOICE = 70450
  DO 70450

CASE CHOICE = 70460
  DO 70460

CASE CHOICE = 70465
  DO 70465

CASE CHOICE = 70470
  DO 70470

CASE CHOICE = 70500
  DO 70500

CASE CHOICE = 70530
  DO 70530

CASE CHOICE = 70550
  DO 70550

CASE CHOICE = 70560
  DO 70560

CASE CHOICE = 70570
  DO 70570

CASE CHOICE = 70580
```

```
    DO 70570

  CASE CHOICE = 70590
    DO 70590

  CASE CHOICE = 70610
    DO 70610

  CASE CHOICE = 70620
    DO 70920

  CASE CHOICE = 70630
    DO 70630

  CASE CHOICE = 70640
    DO 70640

  CASE CHOICE= 70650
    DO 70650

  CASE CHOICE = 70730
    DO 70730

  CASE CHOICE = 70740
    DO 70740

  CASE CHOICE = 71700
    DO 71700

  CASE CHOICE = 71850
    DO 71850

  CASE CHOICE = 72400
    DO 72400

  CASE CHOICE = 73000
    DO 73000

  CASE CHOICE = 73060
    DO 73060


ENDCASE
ENDDO (WHILE CHOICE # 4)

USE
CLEAR
```

*QUIT